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—AND—
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THE AMERICAN

Meteorological Journal.

VOL. I. DETROIT, FEBRUARY, 1885. NO. 10.

CURRENT NOTES.

A CURIOUS result of long continued drouth was experienced in Southwestern Virginia and neighboring districts in late autumn and early winter. The springs there are largely mineral, and the absence of rain made the mineral constituents held in solution, so concentrated that the water became unhealthy and eventually dangerous. The mortality was considerable for so thinly populated a region.

FROM the daily press we learn that an important arrangement has been made by the meteorological bureau of Great Britain, and the New York maritime exchange branch of the United States signal service bureau. It has been agreed that upon the arrival at this port of steamships from English ports, a description of the weather encountered by each vessel after passing meridian 45 shall be immediately cabled to the British meteorological bureau. By this means vessels about to start across the ocean from the other side will be warned concerning the weather they will have to encounter, and they may prepare themselves to meet fierce storms if any such be in their paths. The expense of this service will be defrayed by the British bureau. Dr. H. J. Penrod will have charge of the signal-service branch at the maritime exchange.

DETAILS are lacking concerning the southern storms of the night of January 11, but they seem to have been of tornadic character. The storms were felt over central and eastern Alabama and central Georgia, and were quite destructive. This begins the tornado season very early.

THE announcement of the great size of Lake Mistassini seems to have been premature. It was made by the officer in charge of the transport party. The expedition, which was organized under the auspices of the Quebec Geographical Society, will not return, probably some 18 months.

FROM the Hydrographic Office we learn that the ship "Occidental" at San Francisco, November 14th, reports at 6 P. M., November 4th 150 miles off Mendocino, had three shocks of earthquake, and a few hours later two more heavy ones. Latitude of Cape Mendocino, 40° 26', N; longitude, 124° 24' W.

A CIRCULAR has been prepared by Professor Kiessling of Hamburg, in the name of the Hamburg-Altona branch of the German Meteorological Society, in which he requests information from practiced observers concerning the characteristics and dates of appearance of the peculiar disc and ring of colored light around the sun, that has attracted much attention during the past year. The phenomena are of two kinds: The first is an indefinitely bordered, smoky, reddish ring that may be seen around the sun in a clear sky; it becomes more apparent when the sun is not far from the horizon, and is best observed when the sun itself is hidden by a building. On very clear days, the immediate neighborhood of the sun, within the reddish border, appears of a dazzling bluish light; this is more strikingly shown from high mountains than from lowland stations. The second appearance is visible in a partly cloudy sky, when the sun is obscured by floating *cumuli;* then a pale red light (schimmer) is seen between the clouds at a considerable distance from the sun; the color varies from a pale lilac to a pale brown-red, according to the altitude of the sun above the horizon. The invisibility of the ring, as well as its presence, should be recorded; and information is also desired concerning any recurrence of the twilight glows during the past or current year. Professor Kiessling now regards these peculiar optical effects, along with the great twilight glows of 1883, as the result of the eruption of Krakatoa. W. M. D.

THE past year was characterized by an unusual number of earthquakes, and the current one promises to be as remarkable. Hardly a day has passed since the beginning of the year, in which one or more have not been reported, and those of Spain have been especially destructive and peculiarly long-continued.

IN the December number of this Journal (p. 337), was given a notice of Signor Francesco Salino's pamphlet, in which he proposes a method for measuring elevations by barometric averages without using the temperatures. Signor Salino now appeals to all who have barometric monthly means extending over several years (preferably 1879–'81), to send them to him. He will furnish his own publications in return. His address is Belluno, Italy. We commend his request to the favorable consideration of our readers. Signor Salino accompanies this request with a restatement (in French) of the problem he has attacked, and modifies somewhat his previous views on the corrections for the month of observation which he had previously considered as depending on the earth's distance from the sun. He now considers them as dependent on the sun's meridian zenith distance (that is, on the latitude of the place), and finds in them some anomalies not yet explained.

A MEASURE was made of the *wave length of the green auroral line* at the Greenwich Observatory in the aurora of Nov. 17th, 1882, the account of which is given in the recently issued volume of Greenwich Observations. The wave length of the line was found to be 5537 ± 4.5 tenth metres. Its usual value is 5569. Several other lines were seen but could not be measured. Accompanying this aurora was seen "a magnificent streak of light, much more brilliant than the great comet, and about a quarter as long again. When first seen it had already risen some 20°, and just at that moment it bore a great resemblance to the comet in general outline. Rising in the east-northeast, and slowly mounting, it seemed to follow a parallel of declination; passed just above the moon, and sank, with an even regular motion, down to the west. It faded somewhat after passing the meridian, and disappeared at about $6^h\ 5^m\ 59'$ G. M. T. It took about two minutes to cross the sky. It slowly increased in length up to meridian passage and decreased after it, its greatest length being about 30°." A similar phenomenon was noticed in New York and Penn. early in September; no view of the spectrum of the English one was obtained.

IT SEEMS that in a *tropical country*, even in high pressure and the dry season, *depressions* can be formed, travel eastward and yield precipitations as in our temperate regions. Mr. Blanford has recently studied the winter rains of Northern India which are of this character. The depressions seem to originate in Northwestern India, and are due to the northern hemming in by the Himalayas.

THE *mean daily area of sun-spots* and faculae for 1882, are measured from photographs taken at Greenwich and at Dehra Dun, India, expressed in millionths of the sun's disk, are, for umbrae 189, whole of spots 1002, faculæ 2154. There were two maxima for the year for each of these elements, viz. April and November. The mean heliographic latitude was 16° north and 19° south; but it varied for each month, reaching a maximum north and south at the time of maximum spot-surface as above. On the whole the latitude had decreased from the year before and was decreasing during this year. The southern hemisphere was more spotted, the ratio between the mean daily areas north and south being $\frac{443}{555}$ =0.8 nearly.

ON the evening of January 15 the citizens of Ann Arbor were presented the spectacle of a *bright auroral glow*, visible in or through a dense cloud stratum. The glow was principally visible in the west, and from 9 to 9:30 P. M. was so bright as to be strongly suggestive of moonlight. At 9 P. M. a flash of light was seen to dance across the northern sky. At 9:02 and again at 9:05 P. M., several streamers were seen dancing along the surface of the clouds in the east.

Most of the time, however, the light was confined to the western sky. The sky for about 20° above the western horizon was very dark, above this it became very bright, gaining its greatest intensity about 25° or 30° above the horizon, from which point it gradually grew fainter up to the zenith. At 9:25 P. M. the glow was very bright, but by 9:30 P. M. it had grown quite dim, and contracted greatly in area. At this time a few scud clouds could be seen drifting across it from the north. At 9:35 P. M. flashes of light were seen near the western horizon. These were bright again at 10:05 P. M. At 10:35 P. M. the glow was no longer visible, and it was very dark out in the open air. Pulsations of the light were visible most

of the time during the existence of the glow. A dense and unbroken stratus cloud overhung the sky all day. There was considerable snow from this during the morning, and about 10:30 P. M. it began to snow again and continued all night. The glow was seen the next night, but less vividly. H. H. C.

THE following is from a recent number of the *Manchester* (N. H.) *Union*, for a copy of which we are indebted to Mr. S. C. Gould, of the *Notes. Queries and Answers.* The note shows with what a vigor the N. E. Meteorological Society pushes its work: "The New England Meteorological Society, in co-operation with the chief signal officer of the United States army, have completed arrangements with the Old Colony Railroad whereby the cold wave flag—a white flag with a black square in the center—will be displayed at the stations of that road. An extension of this arrangement is in contemplation so as to bring the daily weather forecasts issued by the signal office into more general notice. Postmasters or town authorities in New England desirous of undertaking the display of daily weather signals are requested to address Mr. W. M. Davis, Cambridge, Mass."

WE take the following from the September report of the Ohio Meteorological Bureau. The *phenomenon of clouds rushing together* is often reported for local storms, but a satisfactory explanation is still lacking.

Prof. F. F. Jewett, the observer at Oberlin, sends the following report of a thunder-storm which occurred at that place.

On the tenth inst. a thunder-storm occurred here of a very peculiar nature and of unusual violence. At noon a shower passed to the north of Oberlin, advancing in an easterly direction, only a very little rain falling in the town. Shortly after one o'clock a small thunder-cloud appeared in the south, one also in the west, and one at the north-west. No one of these extended over a large area, nor had any unusual appearance. Very suddenly and unexpectedly these three clouds united directly overhead with one another, and with the cloud which had before passed to the east, and which appeared to return. On uniting they poured down rain in sheets and occasionally cast down hail-stones as large as hazel-nuts. The lightning was very vivid and played some curious pranks. Selecting a large brick-house in the western part of the town, unprovided with lightning-rods, it struck the top of the chimney, rattling off a few bricks, but otherwise doing no damage except clearing the chimney almost entirely of soot, and spreading about "two bushels" of it upon the parlor carpet. The lightning seemed not to enter the house, as no traces of it were observed inside the dwelling.

DURING the coming tornado season, it is to be hoped that the attention of persons who are so unfortunate as to have opportunity of watching a tornado destroy their neighbor's homes, may be especially directed to the careful noting of certain peculiar phenomena that have not yet received enough direct and critical observation. Cannot something more definite be discovered than is to be found in most accounts of these storms, about the light and dark clouds which sometimes are seen to rush together as the tornado is formed? Why do their colors differ, and how do they combine? How high is the top of the funnel? What is the motion of the heavy overlying clouds from which the funnel hangs, and of the still higher, upper clouds, if they can be seen? What is the motion of the cloud fragments in the funnel itself? Some meteorologists contend that an ascending current is not yet proved to occur in the center of the storm; others, who to our mind have the better side of the question, believe this is sufficiently established. At all events, the case is not to be settled by vague description of the downward plunging of the funnel, which, as is well known, may be purely an appearance resulting from the growth of the cloud downward by condensation of new particles faster than they are carried aloft by the wind, which is continually ascending, as Franklin long ago suggested. What is the meaning of the broken clouds which are described as descending at a little distance outside of the whirl before they are drawn into the vortex? What is the direction of the wind several miles north and west of the tornado? How near to the funnel cloud does hail fall? Of course it is an easy matter to sit quietly at home and frame such questions as these, and a very different and difficult one to retain presence of mind and keenness of observation during the near passage of a roaring tornado; but now that a tornado has actually been photographed, it does not seem too much to expect close and discriminating accounts of these storms from some eye-witnesses who are prepared to look upon them coolly, intelligently and critically. If sketches might at the same time be made by a practiced hand, they would not only be of scientific value, but they would doubtless bring a fair price if offered to some of our illustrated papers. W. M. D.

DETERMINATION OF AIR TEMPERATURE AND HUMIDITY.

(*Continued from January number.*)

Prof. Angot, in working up a long series of observations, found it necessary to omit all between 32° and 28.4°. Nearly all investigators have assumed, or obtained by experiment, a large difference when comparing readings just above 32° with those below the same. It is a little surprising that the line of demarcation should be set at exactly 32°, it would be learned by any experimenter in a short time that the wet bulb temperature can be lowered at times to 27°5 and even lower before any ice is formed. It is important that if any distinction is made it should be between water and ice, and not whether the wet bulb is above or below 32°. "Fronde" works admirably just at and below 32°, as well as at other points, and shows that there is no difference in the results whether there be water or ice.

One of the requirements of modern science is that we may be able to repeat our experiments again and again, at the same time, and with only slightly varying results. It is believed that the best system heretofore proposed for obtaining reliable psychrometric results falls far behind this simple and inexpensive device, not only in the rapidity, with which the lowest reading may be had, but also in the accuracy of repeated attempts, after rewetting, under the most unfavorable conditions. It is confidently expected that only a short time will now elapse before we shall have a rigid formula for the psychrometer, which future investigators will only have occasion to change in minor details instead of radically, as has too often been the case in the past. The following table gives a few of the observations thus far made with "fronde" and Alluard's condensing hygrometer:

DATE.	NO. OF OBSERV'T'S	DEW POINT.	t' WET BULB.		t DRY BULB.	$t-t'$	A		RELATIVE HUMIDITY.			XI—X.		XI—XII.	
			Water.	Ice.			Water.	Ice.	Observed.	Computed.	Angot.	Water.	Ice.	Above 32°.	Below 32°.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.
1884.															
Oct. 10	3	36.4	52.7		69.3	16.6	.00066		30	29	27	+1		3	
"	3	29.6	49.2		66.3	17.1	65		25	24	23	+1		2	
"	3	28.1	47.6		63.3	15.7	67		26	26	25	0		1	
"	9	33.2	51.1		68.7	17.6	63		27	25	25	+2		2	
" 13	2	52.2	63.1		79.9	16.8	67		38	38	34	0		4	
" 16	3	31.5	50.1		66 5	16.4	68		27	27	26	0		1	
" 24	8	22.6	29.7		34.0	4.3	61		62	59	50	+3			12
" 26	16	24.7	31.1		34.8	3.7	68		66	66	57	0			9
Nov. 6	1	17.0	25.9		29.8	3.9	71		57	58	49	−1			8
" 6	7	17.2		25.9	29.8	3.9		.00070	58	58	49		0		9
" 6	10	11.9		23.1	27.4	4.3		69	50	50	42		0		8
" 7	12	21.6		26.9	29.7	2.8		65	70	70	64		0		6
" 7	8	21.7		28.8	32.8	4.0		68	62	61	52		+1		10
" 7	4	21.1	29.5		33.9	4.4	68		58	58	48	0			10
" 7	4	21.1		29.7	34.0	4.3		72	58	59	49		−1		9
" 7	16	22.0	30.2		35.1	4.9	62		58	56	46	+2			12
" 7	2	25.9	36.3		43.2	6.9	65		50	49	45	+1		5	
" 7	16	24.4	37.7		46.0	8.3	69		43	43	39	0		4	
" 8	20	17.2	32.3		40.0	7.7	69		38	39	34	−1		4	
" 8	24	16.6	29.4		35.8	6.4	66		44	43	33	+1			11
" 8	2	17.8	27.0		31.0	4.0	74		56	58	50	−2			6
" 8	16	17.8		26.7	30.6	3.9		73	57	59	50		−2		7
" 10	16	21.2		21.8	22.0	0.2		93	97	97	97		0		0
" 10	20	25.2		27.1	28.25	1.15		61	87	87	82		0		5
" 10	20	31.3	33.0		34.6	1.6	46		88	85	82	+3		5	
" 10	20	33.6	37.2		40.05	2.85	62		78	77	74	+1		4	
" 14	12	19.4		28.7	33.3	4.6		69	55	56	46		−1		9
" 14	6	20.2		29.6	34.6	5.0		66	54	54	43		0		11
" 14	16	19.6		30.4	36.7	6.3		61	49	45	34		+4		14
" 14	16	19.6		31.9	39.3	7.4		60	44	40	28		+4		16
" 14	12	19.5	32.8		40.9	8.1	60		41	37	35	+4		6	
" 14	16	19.8	34.3		43.2	8.9	62		38	35	32	+3		6	
" 14	20	17.3	36.5		48.2	11.7	62		28	25	24	+3		4	
" 14	7	17.8	37.3		48.0	10.7	70		29	30	28	−1		1	
" 14	12	21.2	35.8		44.8	9.0	64		38	37	33	+1		5	

The above table includes all the observations in which t', or the wet bulb temperature was below 32°. I have separated the values of A so that column VIII contains all values with water on the wet bulb and IX contains the values with ice. It will be noted that the values of A agree in the two columns, the value .00093 on Nov. 10, is not to be considered, as it is found with only a very slight difference between t and t'. Column X gives the relative humidity as observed with the Alluard apparatus. In column XI are placed relative humidities from a value of x computed by the

formula: $x = f - .000678\ (t - t') \times \frac{5}{9} \times 30$ or $f - .0113\ (t - t')$, prepared from the mean of 1400 observations. Column XII contains the relative humidity from Prof. Angot's table prepared in 1882. Columns XIII and XIV give difference of relative humidity with water and ice, as observed or computed. The preponderance of + signs shows that the constant .000678 is a very little too large owing to the fact that too much weight was given the observations when $(t - t')$ was small. When $(t - t')$ is small a greater difficulty is experienced in observing the dew point, and, moreover, it is probable that the wet bulb temperature itself is a little too high, or else the dry is too low; the former possibly, because protected by the muslin and copious moisture as well as reading too high from contraction of ice film; the latter from the settlement of nearly invisible dew or hoarfrost at low temperature upon the dry bulb. A large number of observations, especially at low temperatures and when the air was supersaturated *i. e.* showed dew or frost particles in suspension, have indicated, after most careful and long continued efforts, a higher reading of the wet than of the dry. Whatever explanation is correct, we find that the values of A may vary very largely from the mean, when there is a small value of $(t - t')$, without producing a noticeable difference between the observed and computed relative humidity.

The last two columns XV and XVI contain differences between the observed relative humidity and Angot's values; XV giving values when t' was above 32°, and XVI when t' was below 32°. The uniform plus signs show that Angot's tables are prepared from psychrometric observations made with too little ventilation, also, the large values of the residuals in column XVI show, as already brought out, the great uncertainty in the ordinary method of observation at low temperatures, and the incorrectness of adopting a different formula for temperatures below freezing.

Another shelter on this principle, *i. e.* of free access of air to the thermometers is the "Renou stand" used in France, and consisting of a simple roof with side pieces on the east and west to shield from morning and afternoon sun. Such a shelter allows too easy wetting by rain and does not sufficiently protect from reflected and radiated heat from surrounding objects. Still another shelter is a single louvred wooden shelter about 1 metre cube, having a double roof and with a slight projection on the upper side of each slat, or a movable blind, to keep out the rain. Such a shelter has all the advantages of a Renou stand without many of its disadvantages. Complete

experiments between this shelter, Wild's and three others have been carried on the past summer and the results will soon be published.

Turning now to the second class of shelters named above, which aim at keeping out all rain and reflected heat, we find two prominent examples. One of these is the Stevenson, 18" long, 10" wide, and 15" high, of double wooden louvres, used largely in England.

The other is Prof. Wild's shelter which consists of an outer shelter, of wooden louvres, over a metre cube, the south side and roof being double boarded with a free air space between the boards, the east and west sides of single louvres of wood and the north side and bottom entirely open. Inside of this shell is placed a cylindrical zinc screen, made in four pieces and so arranged upon a central spindle as to permit of revolving the two opposite pieces so as to gain a view of the thermometers inside. This inside screen is provided with a revolving fan for ventilation. These two patterns differing so widely have been compared side by side at Kew for over two years with the result that they differ by less than .1°. These comparisons consist of readings at 9 A. M. and P. M. of dry and wet bulb thermometers together with maximum and minimum.

The mere agreement of these shelters proves nothing as to the accuracy of either, but such agreement enables us to predict approximately in regard to one of them if we know the actual behavior of the other.

Prof. Mohn, in a few experiments, has determined the fact that the Stevenson shelter gives much too high temperatures in full sunshine, and as will be shown later, this is precisely what has been found, in regard to the Wild screen, by an independent method of investigation. It should be noted that the mean of observations at 9 A. M. and P. M. cannot give a very clear view of the actual discrepancies between any two shelters, but we need hourly observations through the day.

It is evident at first sight that Wild's zinc screen would have very little natural ventilation. This is shown by the experiments of Sworykin published in *Repertorium für Meteorologie*, vol. XII. No. 8, page 23.

Sworykin found with a wind velocity of 4 metres per second (9 miles per hour) a relative humidity 11.7 per cent. lower with ventilation by the fan than without, and at a velocity of $7^{m \cdot p \cdot s}$ (15 $^{m \cdot p \cdot h}$) it was 4 per cent. lower after ventilation. Another proof of this lack of ventilation adduced by Dr. Assman, and corroborated by the writer of this, is that when an observation is to be made, the

wet bulb temperature immediately falls, upon opening the screen. Prof. Wild rather surprisingly attempts to answer this objection by stating that the temperature falls because of radiation into space; this explanation, even if we grant that such radiation would be appreciable under the circumstances in question, is entirely unsatisfactory for the following reasons: 1st, the dry bulb does not fall equally with the wet. 2nd, the wet falls about the same, whether the sky is overcast or not, and it is evident that under the latter condition nearly all radiation into space is cut off. As a matter of fact, if it were not for a single consideration, to be explained later, the tendency would be for the temperature to *rise* on opening the shelter, as would be very quickly learned by placing a thermometer on the north side of a wooden shelter entirely exposed to radiation into space. Such a thermometer will indicate at midday a temperature 2 to 3 degrees higher than inside the shelter.

Prof. Wild assumes as a criterion for the accuracy of his shelter the fact that on an average there is only .1° C .18°F. difference when the fan is still and when in motion. In order that this may be accepted, however, it is necessary to show, first, that the air which is brought in contact with the thermometers is unaffected by the surroundings—this, however, is not possible since the south side has no ventilation in front and in consequence the boards must be heated much above the air temperature; second, that this air is in no way affected by the motion of the fan, and third, that the fan produces proper ventilation. The latter point is important; experiments indicate that such a fan operates only at its circumference, so that it is highly probable that only a very slight velocity of air current passes the thermometers; the very fact that so little change is produced would seem to show that there really is very little ventilation. I have not been informed as yet whether Prof. Wild propels the air into the shelter or, by reversing the fan, draws it out. My own experiments show a considerable decrease in temperature with ventilation inward; it is evident that with ventilation outward the effects produced would be practically nothing.

Experiments also indicate various serious objections to this screen, *e. g.*, at Tiflis it was found that it gives a temperature even as high as 1.8° above the truth, at 1 P. M., on still days in summer; in like manner I have found at Washington that in August and September on an average, taking all kinds of weather between 9 A. M. and 3 P. M., Wild's screen without ventilation gives about 1° too high value and with ventilation .5° too high. Prof. Wild suggests

that in latitudes lower than 45°, say, it will be necessary to double-board the east and west sides, as well as the south. This is a most remarkable point; a less ventilated arrangement it would be difficult to find except a closed box. Even if the wind were due north there would be no natural ventilation. It would be interesting to have experiments tried with this modification, but we could not consider that the true temperature would ever be obtained except at rare intervals as it oscillated back and forth by that of the screen.

The true explanation of the higher reading of this screen in the day-time is not far to seek. A closed or nearly closed metalic vessel will assume a temperature very nearly equal to t_{bl}, *i. e.*, a temperature from reflected heat, if direct solar radiation is cut off, as much higher than t_{br} as that is higher than t_a. We may, then, consider that without ventilation this shelter assumes the t_{bl}, and that ventilation even cannot wholly remove the evil effects of the close screen. These views are corroborated by actual observation of t_{br} and t_{bl}. In October, 1883, in an open shelter, the mean of 100 observations gave t_{br} 73°.4 and t_{bl} 74.2; in a Wild screen the corresponding nearly simultaneous values were t_{br} 74.8 and t_{bl} 75.0. The open shelter was of the same size as the outside single-louvred wooden shelter of Wild's screen, the north side having louvres as the other sides, but Wild's having the north side open to the sky. These observations show that while t_{bl} was .8° higher than t_{br} in the first shelter, the two were nearly the same in the second, but the t_{br} was 1.4° *lower* in the *first* than in the second, also the presence of the zinc screen cutting off a part of the natural ventilation seemed to produce a slightly higher t_{bl} in it than in the first.

Now, if we consider t_{bl} as much higher than t_{br} as that is higher than t_a in the shelter, we shall have t_a in the open shelter 72.6° while in the Wild screen it was 74.6° or 2° higher. This agrees almost exactly with the results at Tiflis. Moreover, the t_{bl} and t_{br} near the zinc, but on the outside were very nearly the same as in the open screen. If it be objected that in the outside of the Wild zinc screen there would be radiation into space through the open north side, this is answered, first, by the fact that the same result was obtained in the open shelter in which all such radiation was entirely cut off, and, second, if we consider the t_a as lower than t_{br}, we still have, after all possible radiation into space, t_{br} too high. We must conclude then:

1. *The Wild screen will give a temperature nearly the same as a black bulb thermometer, no matter how many of the sides are doubled.*

2. *This temperature must inevitably be higher than the true air temperature in the day time.*

3. *We shall always have a better result in the day-time by taking away the Wild screen, and hanging the thermometer in the outside shelter.*

Prof. Wild, in *Repertorium für Meteorologie*, vol. 6, No. 9 p. 16, has given a number of comparisons between his screen and the thermometer "fronde." These show the superiority of the latter in so marked degree that I transcribe the results as good evidence for this, although Prof. Wild attempts to show, from these or others, we may suppose somewhat similar, just the contrary.

Comparison by Prof. Wild of his zinc screen and a thermometer "fronde:"

HOUR.	CLOUDS 0—10.	WILD'S SCREEN.	"FRONDE."	DIFF.
3 p	3	20.3°	21.5°	—1.2
9 p	4	17.2	17.4	—0.2
8 a	3	17.4	18.6	—1.2
7 a	8	15.5	16.4	— .9
1 p	5	19.8	21.0	—1.2
1 p	0	15.0	16.8	—1.8
1 p	3	21.4	22.4	—1.0
3 p	0	20.8	21.2	— .4
3.30 p	0	20.6	20.8	— .2
4.30 p	0	21.0	20.8	+ .2
6 p	0	20.5	20.1	+ .4
7 p	0	17.6	17.4	+ .2
8 p	0	15.9	15.7	+ .2
9 p	0	14.4	14.0	+ .4
2.30 p	5	14.4	14.7	— .3

Prof. Wild states that because of solar radiation the "fronde" gives .7° too high value at midday this is not shown at all by these observations however, for these tend to show the opposite. With a *clear sky* "fronde" was lower than Wild's in .7of the cases, and with a partly clouded sky, when solar radiation was nearly cut off, under which circumstances "fronde" will give nearly absolute values, the Wild screen read about 1.8°F. too low. These experiments are far too few to establish the merits of either system, but certainly the evidence, in favor of the 'fronde' under proper conditions, giving correct values and also that Wild's screen gives incorrect values, is sufficiently strong to prove that if either is to be assumed as a standard it must be the former and not the latter. It should be borne in mind that even if we employ a perfect ventilation, yet the maximum and

minimum temperatures necessarily unventilated, will be entirely untrustworthy unless the shelter gives t_a without ventilation.

The actual differences between shelters of different patterns will be found surprisingly small. We now need observations of t_{br} and t_{bl} in various shelters, we also need an investigation into the relation existing between t_a, t_{br}, and t_{bl}.

H. ALLEN HAZEN.

November 20, 1884.

THE SOUTH CAROLINA TORNADOES IN FEBRUARY, 1883 AND 1884.

Not long ago I examined carefully day after day, as time permitted, over a mile of the track of the tornado of April 23rd, 1883, using a pocket-compass to determine the exact direction in which the fallen trees lie, and before I had made much progress in the undertaking a certain degree of regularity and order in the confused heaps of destruction began to impress itself upon me, and, as the work proceeded on to completion, to my astonishment I found that the same order prevailed with invariable precision throughout the whole apparently chaotic field.

Beginning at the western limit, where the storm first made its descent on the hills, I found the track quite narrow, not over a hundred yards in width, and the trees were thrown down almost exclusively from south and southwest, and wherever they crossed each other, those thrown from the southwest were invariably on the top. Some three hundred or more yards to the north of this point there were a few trees thrown from a westerly direction.

Continuing the inspection to the eastward, there was little or no difference in the condition of the track for some four or five hundred yards, but here some of the fallen trees began to have an inclination from the eastward, one lying from south by east, several from south-southeast and one as far round as southeast by east; this one lies under one from south-southeast and this under one from west.

In this part of the track is a remarkable interlocking of two large trees, a pine and an oak, which will receive further notice hereafter.

The track now also begins to widen, and about two hundred yards further on, where it crosses the public road running from Charleston to Camden, it is something over two hundred yards

wide. On the east side of the road the track widens out rapidly both to southwards and to northwards. Proceeding along the south border eastwardly for from two hundred and fifty to three hundred yards, I found the track to differ scarcely at all from that portion already described, the fallen trees lying chiefly from south and southwest, here and there some from south by east or south-southeast and one broken from west-northwest, the upper fragment still attached to the stump. Proceeding onwards, the direction of the fallen trees now changes towards the east, so that by far the greater number lie from southeast or from some point between southeast and south; and this order continued for about five hundred yards, at the end of which distance I came to the fine residence, Brookland, situated in the southeastern border or limit of this first storm area. Around this house, to the east, south and west, the trees were thrown from a southeasterly direction, and on the north side some were thrown from southeast, some from southwest. On the southern side of the house the top of a chimney was carried away level with the roof and dropped, a mass of rubbish, some ten feet to the south of the building, evidently the work of the west wind in the last, final swoop over the field.

Leaving Brookland now and proceeding in a northwesterly direction, I found, in the course of two hundred yards, several trees lying from southwest and south, also a cluster of very large pines thrown from east-southeast. About two hundred yards on was one from east-northeast, then, a little farther on, one from north-northwest. After this I proceeded in a more or less curved line for three hundred and fifty to four hundred yards, gradually changing my course from northwest to west, and in this space the trees were lying as follows: N., N. N. W., N. E., N. W., N., N., N. N. W., N. N. W., N. W., N. W., W. N. W. Then, turning towards the southwest and proceeding about two hundred and fifty yards, I struck the public road where it is crossed by the north border of the storm-track. The fallen trees along this space were, without exception I think, lying from west-northwest and west or some intermediate point. Next I took up the line of observation through the centre of this irregularly circular area from west to east or west-southwest to east-northeast, a distance I estimated at about seven hundred yards from the public road to a point about two hundred and fifty yards northwest of Brookland house; but my course was by no means a direct one, for in many places the trees lay so thick that it was impracticable to go over or under

them; I had to go around and then strike as well as I could the direct line on the other side. Along this line I found the trees crossing each other as follows: First by the roadside, three, the bottom one from the south; next above from the southwest and one from west on top; then one from southwest crossed by one from southwest by west; then one from west-southwest crossed by one from west; then one from southeast crossed by two, one from southwest the other from southwest by west; then one from southeast crossed by one from south, and this crossed by one from west; next, two side by side from southeast and southeast by south, over the bases of which is one from west by north, and over their tops one from southwest; over this is one from south, and over all one from west by north. Then, a little farther on, is one thrown from east by south, over which is one from north-northwest, and over this is one from west by north; then one from southeast, over which is one from north. It is seen from these crossings that the trees thrown from southeast lie under those from south; those from south lie under those from southwest, with one single exception, and those from southwest, without exception, under those from west. Also those thrown from southeast and east are under those from north and north-northwest, and these under those from west. From this arrangement of the fallen trees it appears evident that the storm began its attack on the eastern side of this area about the same time that it fell upon the western limit, and from the east worked backwards towards the west along both south and north borders at the same time, all the currents driving towards the central line running from west-southwest to east-northeast through this irregular circular area, and some of them meeting at a common centre or rather arriving in quick succession and regular order at the centre as follows: On the south side, the east and southeast first, then the south, then the southwest, then the west, and on the north side the currents from east and northeast first, then the north, then the northwest and last again the west. Here where all these currents met in very rapid succession there must have been a more or less violent whirl generated within a very limited space. At the base of a broken pine just here there is an accumulation of debris, broken limbs, branches and brush heaped together in a manner similar to the accumulations of floating debris left by freshets here and there along water courses, and termed by the illiterate "harricanes." This storm area, in figure, is not unlike a capital Q, with a straight instead of a curled tail, and the O or head

considerably elongated. Thus draw the O or head with a long diameter in proportion to the short diameter as 7 to 4 or 8 to 5, and the tail about the length of the long diameter of the head. Now bisect the O or head both ways by drawing the long and short diameters and thus divide it into four quadrants. Along the tail, beginning at the end, the fallen trees lie chiefly from south and southwest, here and there is one from a more westerly direction, but along the last third, towards the base of the tail, some trees are lying from south-southeast and southeast. The southwest quadrant of the head is in most respects similar to the tail, the trees lying chiefly from south and southwest, a few here and there deviating somewhat eastwardly and a few from the westward. Throughout the southeast quadrant the trees lie chiefly from south-southeast, southeast by south, and southeast. In the northeast quadrant, except as the central space is approached, the trees lie very scatteringly in directions from east, northwest and intermediate points, and in the northwest quadrant they lie from northwest, west and intermediate points chiefly from west-northwest and west. In the southwest quadrant many trees were broken off at various heights, from ten to fifty feet (nearly as many broken as there were uprooted), and the destruction in this and the northwest quadrant appears to be greater than elsewhere in the head, though in the southeast it is only slightly less. In the northeast quadrant, however, the destruction is decidedly less than in the other three. Proceeding now in a direction east-southeast from Brookland through a field about two hundred yards wide, I then descended the hillside, through forest for about three hundred yards farther, and here in the valley were two trees, not far apart and in line, thrown from the west. Crossing a brook a little farther on, I ascended the opposite hillside for about two hundred yards and then struck the second step or area of the storm. The condition of the track here conforms in all respects to that of the tail of the Q in the first area already described, except that it is shorter, not being more than four hundred yards in length, before it unites with the head. The storm had evidently begun to decline in intensity, for the area forming the head of the Q was only partially developed, as shown by the absence of the southeast and northeast quadrants, in consequence of which there was no inrush of the east and north currents. The arc of the northwest quadrant was also straightened out northwards, and runs in a nearly direct line from south to north. Along this line the south wind, unopposed by the north, rushed through

to the north border, a distance of about three hundred yards, and there the destruction suddenly ceased to northwards, but the west wind striking in now, pursued its way to the next area, thus giving a zig-zag form to this and the remaining portion of the track. The fallen trees throughout this space lie from southeast, south, southwest and west and incumbent on each other, when found crossing, in the order before stated.

Within the southwest border (the southwest quadrant) of this area is situated the Episcopal parsonage, around which many trees were uprooted, thrown from southeast, south, southwest and west. This dwelling was occupied by the Rector of the parish, and Brookland was occupied also, at that time, by a young lately married couple, all of whom were so taken by surprise by the sudden and unexpected descent of the storm that they scarcely had time to collect their thoughts before the winds in their full violence had swept by, and only after they had viewed the scene of devastation on all sides around them could they realize fully the imminence of the danger through which they had safely passed. They say that there was a slight rocking or tremulous motion in the houses for a brief space of time, and that the crashing of the falling trees was entirely drowned by the terrible roar of the winds. That these two buildings should have escaped uninjured amidst the wild destruction on all sides and immediately around them is wonderful, inexplicable, except through the merciful interposition of a Superintending Providence who rules the winds as well as the waves; the "stormy wind fulfilling his word."

A half mile beyond the parsonage to the eastward the grounds are for the most part under cultivation and the succeeding steps of the storm are indistinct, though from the felling of trees around different residences and along the roadsides it is apparant, I think, that there were three more steps or areas, about a mile apart, where the winds concentrated but with continually decreasing intensity, till at the last, beyond which there are no traces of the storm, only a few trees were thrown down from south, southwest and west.

The conclusions I arrive at from the above facts are: First, that this storm was characterized by two fierce currents of wind which prevailed throughout its whole course; one from the south the other from the west; the former always preceeding the latter by a short but appreciable space of time. Next, that the storm was not a continuously or uninterruptedly progressive one, (did not progress by bodily transference) but that it progressed by steps or successive transplantings, one step differing from another according as cir-

cumstances affected the intensity of the storm or as the causes which produced it became modified.

Every one has, no doubt, of a dry, clear and calm day sometimes observed and watched a little cloud, which, appearing like a puff of steam in the sky, gradually swells out and becomes as big as a house, but now instead of increasing further it begins to decrease, melting away gradually till it finally disappears, but before vanishing another little puff makes its appearance a little way in advance or to leeward of it, and going through the same changes, makes way in its turn for another, and so on till some alterations in the atmospheric conditions put a stop to the succession and they cease to appear.

In some such manner, I think, this tornado must have advanced in its destructive course, except that seconds could scarcely have kept pace with its wild and swiftly changing movements, whilst minutes wait upon the little dry-weather puffs. Thus, about the time that the winds, all except the west, had completed their work in the first area about Brookland, another area of low pressure, or maximum low pressure was in process of formation in the vicinity of the parsonage, and here the bands of the south were marshalling their forces anew, preparatory to the tiger-like charge, while the west, like the rear guard of a vandal host, was dealing the final *coup de grace* to its helpless victims here and there, sweeping over the field of desolation as though in mad haste to join its ruthless comrades of the south in the attack on the next area devoted to destruction.

As already stated, there must have been a more or less violent whirl, within a very limited space, where the different currents concentrated, but among the fallen trees I have no where perceived any evidence of a whirling or twisting force. Without exception the appearances indicate a force or forces acting irresistibly, suddenly and directly as a cannon shot from whatever direction they may have come, south, east, north or west. The broken trunks of a number of trees still remain attached to their stumps, and the bark and fibres of the wood connecting the stumps with the upper fragments, pass from the one to the other, without a single exception in straight lines, there is in no case the slightest twist. Many uprooted trees appear to have been thrown down as though they had been set in a ball and socket joint, the broken roots and adherent earth forming the ball, and the cavity produced by the detachment of this mass forming the socket, in which the tree

revolved, leaving no hole at the base, but a mound of earth instead with the broken roots protruding from it. In the sudden revolution the base of the tree, instead of being blown forwards, has slid backwards into the cavity, and in these cases they were prostrated with such violence that the trunks, some of them over three feet in diameter, have been more or less buried in the earth for four or five feet above the base. This condition would seem to indicate that in this storm the currents in some places acted with a downward more than an upward force. Then in some places the currents seem to have acted within very circumscribed limits, with the sudden violence of an explosion and then ceasing as suddenly; thus, in a clump of half a dozen or more trees only one has been broken or uprooted as though singled out for destruction, the others having suffered no injury. Again in other places the destructive current may be traced many yards by the line of fallen trees. The different currents also seem to have been restrained within fixed bounds, for in that portion of the storm area represented by the head of the Q, the southerly winds do not pass to the north of the long diameter, neither do the northeast and north pass to the south of this line, nor is the east found to the west of the short diameter but the west and occasionally the northwest are seen to have swept everywhere throughout the storm area, or central track.

Another singular feature is the condition in which a clump of scrub pines were left by the storm. The clump is situated in the southeast quadrant of the head of the Q and apparently the outer dry bark was blown off the stems all around for a foot or two above the ground. It is evident that just in this portion of the track many currents from different directions followed each other in quick succession from the east, southeast, south southwest and west, and the small pines being violently bent from these various directions the dry, friable bark was detached from the stems at the part where the greatest strain and curvature was experienced.

My residence is situated about half a mile to the north of the track of this storm, and during the time of the development and on ward progress the wind shifted continually, backing around from east to northeast, north, northwest and west, and increasing rapidly in violence with each change of direction, till from a light easterly breeze, it became a high northwest and west gale in the course of ten or fifteen minutes, and then as rapidly subsided as the change of direction continued on to the southwest and in the course of an hour it was back again to the east, a gentle breeze. The lower

clouds changed their course with the wind but always one point or 45 degrees behind, so when the wind was north the clouds were moving from northeast, and this relationship was preserved till they both returned to east.

On the 19th of February last, a similar storm passed three miles to the north of my position about 11 P. M., and during its progress, and for some time before and after this brief period, a steady, strong south wind prevailed. Just at the time, as I suppose, that the tornado was raging along the nearest portion of its track, immediately northwards there occurred two sudden, violent gusts of a few seconds duration, but without any change in direction from the heretofore steady south wind. Within an hour after the passage of the tornado the wind had veered to southwest and subsided to a gentle breeze. From these facts as to the course of the wind on the north and on the south sides of the storm tracks, I infer that similar differences in the directions of the winds north and south of the track always attend such storms and form one of the many characteristic features of the tornado. The track of the latter storm (Feb. 19th.) as far as I have examined it, conforms in all respects to a like part of the track of the storm of April 23rd, 1883. Trees prostrated from the south lie under those from the southwest and these under those from the west. One very large yellow pine, over three feet in diameter, was broken off a foot or two from the base. The roots seemed to be so strong and firmly imbedded in the earth that before they could be moved, the strain upon the trunk became too great for further resistance and it snapped like a pipe-stem, and the tree was hurled to the ground with such violence that the huge trunk was not only broken into several pieces, but the fragment next the base, twenty to thirty feet long, was split longitudinally into several pieces as though a wedge and maul had been applied to it. I could perceive no marks of decay anywhere about the trunk of the tree, the wood appearing to be quite solid throughout.

The most astonishing feature in these two storms appears to me to be the unvarying order in which the winds or currents from the different directions successively follow each other.

Imagine hundreds of pieces of artillery posted throughout this storm area of a mile in length and from one hundred to four or five hundred yards in width, and pointing in all directions as the prostrate trees lie. Would it not require the nicest mechanical preparation and arrangement and the most skillful mathematical calculations and engineering to fire off each piece wherever placed,

at the precise time and in the regular order in regard to the pieces pointing in other directions so that there should be no mistake, no deviation from a fixed rule? How vastly more wonderful, how incomprehensible, when one reflects, that the free flowing, wildly rushing winds are so controlled, so held in subjection to fixed laws that each one with unvarying precision strikes in its regular and proper order as though it were a blast issuing from a cannon's mouth:

> God moves in a mysterious way,
> His wonders to perform;
> He plants His footsteps in the sea,
> And rides upon the storm.

The brevity of the interval between the striking of the south and southwest blasts is very remarkably and beautifully illustrated by the position in which two trees lie, one having been thown from south due north and the other from southwest by west to northeast by east. The former was a stately pine about four and a half feet in diameter, and dividing into two forks eighteen feet from the base. The two forks or trunks stood directly north and south of each other; the south one is three feet in diameter and rose to the height of a hundred and thirty-five feet; the north one is two feet diameter at the fork and rose to the height of a hundred and twenty-five feet. Just at the fork the main stem is five feet through, and the two forks stood like two shafts nearly a hundred feet without a branch. The north fork of this tree lies on the ground while the south fork inclines very gradually upwards. In the direction north-northwest from the pine a majestic white oak, three and a half feet diameter at the base, was thrown from southwest by west to northeast by east. According to the rule applicable to the case the oak should lie on top of the pine; possibly the pine may have been retarded, the fraction of a second in its fall by its great size or on account of its having two stems; at all events the top of the oak was caught by the larger south trunk of the pine which now lies locked in the arms and resting on the main stem of the oak. The broken top of the oak projects some ten or fifteen feet beyond the crossing, and a large branch partially split from the main stem is jammed against the pine. The following are the measurements. From base of pine to crossing of the oak, due south to north seventy-five feet. From base of oak to crossing southwest by west to northeast by east thirty-eight feet. From base of pine to base of oak, south-southeast to north-northwest, centre of

base to centre of base, sixty-two feet or from nearest points of the circumferences of bases, fifty-seven feet. At the crossing the two stems of the pine are four and a half feet apart.

Will not the above angles and measurements furnish the terms of a proposition, the solution of which will give the distances traveled by the pine and the oak before they met? Then will not the difference between these distances enable an expert mathematician to compute, by a close approximation if not exactly, the interval of time which intervened between the starting of the pine and the starting of the oak, and as it is not improbable that the blasts from the different directions follow each other at about equal intervals, might not the calculations be extended so as to include the whole series from beginning to end of the storm throughout this area of about a mile in length?

I hope that the above facts in relation to the tornado track here, may, through your widely circulating and valuable journal, be brought to the notice of persons living in the vicinity of the tracks left by the various storms of last February and other dates, and that some may have their interest so excited as to cause them to examine the tracks near them, and ascertain whether the features presented there correspond to the description I have given.

W. W. ANDERSON, M. D.

STATEBURGH, S. C., Aug. 13, 1884.

THE EARTHQUAKE OF SEPTEMBER 19, 1884.

Between 2 and 3 in the afternoon of Sept. 19th an earthquake was felt through Ohio, Indiana, and southern Michigan and in the adjoining States. The data which follow were derived from newspaper reports, the reports for September of the Signal Service and the Ohio Meteorological Service, and from private correspondence. The reports have been abbreviated as far as could be done, leaving only what is necessary to enable each student of earthquakes to decide as to the accuracy of the conclusions drawn. The localities follow in the order of their longitudes, or nearly so. The times are reduced to central standard time, and these are inclosed in parenthesis.

LEETSDALE, Allegheny Co., Penn. Two shocks; sufficient to cause windows and crockery to rattle. Time (2:35).

WHEELING, W. Va. Three shocks. The first was mild and was felt only in the central portions of the city; the motion was undulating without jar. The

second came "a few moments" later and was a succession of abrupt jars, lasting 5 seconds and rocking some portions of the city like a cradle. Wheeling Island felt this most severely. Pictures and similar objects were thrown down, tall campaign poles were seen to quake, the customs officials indulged in a stampede, the water in the river foamed distinctly and the sand-banks laid bare were seen to quiver. The third shock followed soon (in "a few seconds"), and was less severe, but more general. The shocks were not felt eastward at Washington and Claysville, but the last two shocks were felt generally over the river part of Belmont county, lying west of Wheeling. The local reports give the time as eight minutes of three (2:14), but the Signal Service gives 2:30. If the newspaper reports were read eight minutes *after* three, the central standard time would be 2:31, and this is probably the approximate time.

PARKERSBURG, W. Va. A single shock, lasting for several seconds. Timid persons were frightened and plastering brought down from the ceiling. The time given is about 3:35 (2:35 central time).

LONDON, Ontario. The shock was severe enough to cause nausea, but no damage. The times given are 3:20 (2:20) in the Toronto *Mail* and 3:25 (2:25) in the associated press dispatches.

DRESDEN, Ontario. "The shock was distinct, like a distant explosion, which seemed to follow the river and vary in force." It rattled dishes and tossed furniture. No hour is given.

WINDSOR, Ontario. The shock was heavy, without noise, lasting about a minute. The hour was about 2:45 (2:17±).

OHIO.

WARREN. Two shocks, a few seconds apart; slight rocking motion from N. to S., causing nausea; hour, about 2 standard time.

CANTON. Slight shock which swayed walls and rattled dishes; direction N. S.; time (2:15). Possibly two shocks separated by two seconds; whole period 5 sec.

MARIETTA. The shock was felt (2.35).

CUMBERLAND. The shock lasted about 30 sec.; motion apparently E. W.

WINCHESTER. Time (2:25).

MASSILLON. About 3 P. M.; lasted 5 sec.

AKRON. Two distinct shocks, generally noticed. Time 2:48 (2:14).

CLEVELAND. Three shocks, each lasting about 4 or 5 sec. and separated by 2 or 3 sec. The entire duration was about 30 sec. A rustling sound was reported by one man. Chandeliers were swung, trees swayed, and doors opened or shut. Accounts of the direction varied, but it was generally described as W. E. Time 2:47 (2:14).

MEDINA. Slight; 3 P. M. (2:27).

WOOSTER. Four or more shocks. They "came from westward; probably west, about 30° north. Book-cases were tilted east and west; beds shaken same. A safe, the front east and west, looking north, hinges on west, and door open about northeast, was shut by the first shock. A force coming from any front, between west and northeast, would have shut it; but a bed standing north and south was rocked sideways. These two facts confine the direction to some point between west, 30° south, and not to exceed 50° north of west." This is by Dr. O. N. Stoddard, observer of the Ohio Met. Service. The same observer gives the time as 2:44½ (2:11½), which he considers closely correct.

MILLERSBURG. The shock shook down dishes from their places and caused much excitement. The time given is 3 in round numbers.

COSHOCTON. Two distinct shocks, running northwest to southeast. They caused considerable alarm but no damage (2:15).

ZANESVILLE. Two shocks lasting about 10 sec., ringing door-bells and doing some damage. The time is given variously from 2:30 to 3.

MCCONNELLSVILLE. Swayed pictures, etc. No sound was noted. About 3 P. M.

ATHENS. Slight; about 3 P. M.

NEWARK. Several shocks of considerable violence. 2:42 (2:11).

ELGIN. Two shocks in quick succession, the latter the heavier. 2:50 (2:19).

MT. VERNON. Quite severe; caused a panic among school-children. 2:40 (2:10).

FREDERICKSTOWN. Threw open doors; set hanging articles to vibrating; duration about 30 sec. 2:40 (2:11).

MANSFIELD. Vibrations continued about 20 sec., stopping clocks, rattling crockery, etc. Time about 2:45 (2:16).

SHELBY. The shock jarred bottles from shelves and alarmed timid people. A "deep-sounding" noise was heard. "Precisely" 2:46 (2:17).

GRANVILLE. Liquids in bottles were thrown into active oscillation; door-bells were rung; duration 5 to 10 sec. 2:45 (2:15).

MILAN. Duration about 15 sec.

NORWALK. Quite severe; dishes broken in cupboards; lasted 2 minutes. 2:45 (2:16).

MT. GILEAD. Three or four separate shocks. 2:45 (2:16).

COLUMBUS. Three shocks; swing chandeliers and pictures and topple down a new arch. Duration estimated 4 to 15 sec.; direction N. S. Time 2:42 (2:14).

BUCYRUS. Severe; rattling glassware, stopping clocks and causing a panic among school-children. 2:40 (2:12).

ANSONIA. Shook buildings violently.

DELAWARE. Vibrates hanging articles and causes a school-panic.

WESTERVILLE. Created some alarm. (2:15).

FREMONT. 2:45 (2:17).

TIFFIN. The shock broke crockery, and upset clocks and vases; cracks were made in the walls of brick buildings and some chimneys thrown down; duration 10 to 20 sec. Time 2:45 (2:17).

FOSTORIA. Shakes loose articles together (2:19).

CALEDONIA. Buildings violently shaken; duration about 5 sec. 2:45 (2:18).

UPPER SANDUSKY. Two distinct shocks; duration 10 to 20 sec. 2:42 (2:15). Direction apparently S. N.

TOLEDO. Distinctly felt; lasted about 15 sec. 2:42 (2:16).

NORTH LEWISBURGH. Undulations very perceptible, with rumbling sound; duration 5 sec. 2:39½ (2:13½).

FINDLAY. It upset insecure articles; duration about 15 sec. 2:45 (2:20).

BELLEFONTAINE. Shook loose articles about; lasted about 10 sec. 2:50 (2:25).

W. LIBERTY. 2:46 (2:21).

URBANA. Furniture displaced. 3:30.

SPRINGFIELD. Trembling sensation, "felt with especial distinctness along the line of the creek where the limestone rocks are nearest the surface."

ARCHBOLD. Shook buildings; lasted 20 sec. (2:13.)

HOLGATE. Stopped clocks. S. W. to N. E.

WAUSEON. "A low rumbling sound, like distant thunder, was heard in the southwest, and a heavy jar shook buildings." (2:15).

NEW BREMEN. Low rumbling sound; two shocks; N. S. direction. 2:45 (2:22).

TROY. Two shocks, distinct, hard, 2 or 3 sec. apart, and each lasting several seconds. 2:40 (2:17).

DAYTON. Distinctly felt and accompanied by a rumbling noise; duration 15 sec.; direction N. and S. Time given as 2:30 (2:07) and (2:10).

MIAMISBURG. Felt generally through the valley.

DEFIANCE. Low rumbling sound, quickly followed by trembling of the earth; the shock broke window-glass and caused several panics. It appeared to travel from south to north and lasted about ten seconds. 2:40 (2:18).

CECIL. Threw goods from shelving; lasted 10 sec. (2:17.)

PAULDING. Severe. (2:15.)

JUNCTION. (Paulding Co.) "I was standing in the yard at the S. E. corner of the house at the time. First came the roaring or rumbling sound, apparently from the north, or nearly so, then the trembling or shaking of the ground, which shook me pretty well and appeared to go south; the whole time was about five seconds. It was thirteen minutes after two P. M. (standard time). The wind, at the time, was from the S. W. Barometer, 29.49; attached ther. 70°. In a store at Junction, on the top shelf, were some pails on the south side of the store; they were pushed back even with the north edge of the shelf. After the shock the pails were moved to the north almost half their diameter. I distinctly heard the dishes and such articles rattle quite loud. The feeling experienced by those in their houses, as described by them, seems to have been as though the house was falling down. L. E. HITCHCOCK."—As reported in the Ohio Met. Rep.

CINCINNATI. The shocks were very perceptible, especially on the bluffs. A crevice 4 in. wide and 30–40 ft. long was made on E. Walnut Hills. The direction was reported in some cases S. N., in others N. S. The duration was brief. The times vary from (2:8) to (2:15).

ANTWERP. Caused plastering to fall and produced great excitement; duration about 15 sec.

KENTUCKY.

LOUISIVLLE. Two slight shocks close together; rumbling distinctly heard; direction E. W. or N. E.—S. W. Time about (3:15).

COVINGTON. Slight.

MICHIGAN.

PORT HURON. The shock moved unstable objects and lasted 15 sec. It was felt over the whole county. 2:45, (2:15).

DETROIT. The shock was appreciable and accompanied by a slight rise in the water of the river; lasted about 20 sec. The times given are (2:12) and (2:13) with preponderance for the former.

ALPENA. "About 2:00 P. M. Probably standard time."

MT. CLEMENS. Sharply felt.

MONROE. Felt very plainly. 2:40 (2:13).

LAPEER. Window glass broken; caused great excitement. 2:44 "precisely" (2:15).

PLYMOUTH. Houses jarred; vibrations lasted about "two minutes." 2:40 (2:15).

BAY CITY. Slight. 2:35 (2:10).

ANN ARBOR. A hollow rumbling was followed by a sharp series of vibrations lasting several seconds. Door-bells were rung, windows were rattled, chandeliers shook and water in pails slopped over. The time by several inependdent observers was 2:41 (2:16).

FLINT. Felt perceptibly, lasted about 6 sec.

CORUNNA. Caused great excitement; undulations E. W. 2:30 (2:06).

EAST SAGINAW. Buildings quivered violently and articles of furniture were rocked to and fro; duration 5 sec. The time was "precisely" 2:35 (2:11).

HOWELL. Vases upset and furniture moved; duration about 10 sec. 2:30 (2:05).

GRASS LAKE. Quite severe. Times given are 2:42 '2:18) and (2:14).

MASON. Doors were opened and small articles moved. "About" 3 P. M.

HUDSON. The shock shook buildings, rang door-bells, stopped clocks, moved chairs and caused a paper printing on the *Post* press to make a double impression the times given are (2:15) and 3:45 (2:22).

JACKSON. Rattled windows. 2:45 (2:23).

LANSING. Caused chandeliers to swing and broke one or two windows. Time (2:12).

CHARLOTTE. Rattled windows and swung suspended objects. 2:40 (2:19).

EATON RAPIDS. Slight but unmistakable.

HILLSDALE. Slight; duration about 3 sec. Times given 2:30, 3, 3:30

MARSHALL. Windows quivered and desks jarred; duration 6 to 7 sec. 2:45 (2:25).

VICKSBURG. Distinct shock with slight rumbling sound.

STURGIS. Decided shaking and jarring with sound like the distant report of a cannon except that it was more rumbling and lasted longer.

GRAND RAPIDS. Slight, lasting 4 to 5 sec. "A little after" 2:40 (2:22).

PAW PAW. Duration about 2 sec.

SCHOOLCRAFT. Three distinct undulations at 3 o'clock.

NILES. Marked vibrations N. S. lasting 6 to 8 sec.. "About" 2 o'clock.

BENTON HARBOR. No damage. Time "this afternoon."

ST. JOSEPH. Buildings shook and windows rattled; duration 5 to 10 sec., about 2:30.

INDIANA.

LAWRENCEBURG. Shock severe enough to be quite alarming; duration less than 30 sec, 2:40 (2:19).

ANGOLA. Three distinct shocks at (2:13) (2:31) and (2:53), the last being most severe. The duration of each was about 15 sec.

AUBURN. Buildings much shaken and much excitement caused; duration about 10 sec., time (2:15).

FT. WAYNE. A distinct tremor lasting about 15 sec. 2:40 (2:21).

LIBERTY. Two shocks lasting several minutes. (2:22).

CONNERSVILLE. Very perceptible; hanging objects were swayed. The oscillations continued about 10 sec. 2:45 (2:25).

METAMORA. Perceptible shock and rumbling noise. (2:15).

VEVAY. The following is from the *Monthly Weather Review* of the Signal Service:

"The following communication has been received from Professor Boerner, of Vevay, Indiana:

VEVAY, IND., *September 22, 1884.*

THE CHIEF SIGNAL OFFICER U. S. ARMY,
Washington, D. C.

SIR: I have the honor to transmit to you the report of an earthquake, and its attendant phenomena as experienced at this station.

Sept. 19th, 2:30 P. M. (2:10): a moderate shock of earthquake was felt in this vicinity; while the vibration was not of great intensity, still many of our people became highly alarmed. The shock was not very perceptible; beyond the rattling of windows and weights of window sashes inside their casings, the jarring of dishes

in pantries, the oscillations of hanging lamps; and many persons did not notice the disturbance at all. I have endeavored to obtain the experience of different persons; some lying on beds distinctly felt the tremor and hastily arose, in great fright, while others walking on the street felt a sensation of unsteadiness. The direction of the disturbance was from north to south with a duration of 3 seconds; it was preceded by a barometric depression of .09 inch and followed by an increased pressure of .02 inch.

Time.	Barometer corrected for temp.	Thermometer.		Tension of vapor.	Rel. hum.	Clouds.	Wind.
		Dry bulb.	Wet bulb.				
		°	°	*Inches.*	*Per cent*		
7 A. M.	29.72	50	48	.296	79	dense fog	nw. (3)
2 P. M.	29 63	76	64	.436	48	5 cir. cu., s. w.	ne. (2)
2:35 P. M.	29.65	76	64	.436	48	5 cir. st., s. w.	ne. (2)
9 P. M.	29.65	67	62	.489	74	8 cu. st., w.	ne. (1)

Very respectfully, your obedient servant,

CHAS. G. BOERNER, *Observer.*"

ALBION. Two shocks which brought down stovepipes and otherwise disturbed household effects: duration about 5 sec. (2:18).

MUNCIE. Two shocks, the first the stronger; windows rattled, and dishes and glass were broken; duration from 1 M. to 1½ M. Sudden rumbling sound. Time, (2:19) or (2:20).

GREENSBURG. Three separate shocks in quick succession, lasting several seconds. 2:30 (2:12).

LIGONIER. Rattled windows etc. The noise was like the rumbling of a lumber wagon but came from the earth. Duration about 20 sec. 2:40 (2:23).

WABASH. Two light shocks "shortly before three o'clock."

ANDERSON. Large buildings trembled violently. people fled from their houses in fear, duration 10 sec. direction, W. E. (2:20).

GREENFIELD. A slight shock was felt throughout Hancock Co. at (2:20).

SHELBYVILLE. Slight shock of about 3 sec. duration. (2:15).

INDIANAPOLIS. Numerous small vibrations which were generally noticed. The direction was from east to west; the time (2:15).

SOUTH BEND. Distinctly felt. 2:30 (2:15).

DANVILLE. Recognized at once as an earthquake. (2:15).

MICHIGAN CITY. "The wave extended east and west, and the vibration lasted nearly a minute"

IOWA.

DUBUQUE. Slight but felt generally in high buildings. (2:05) ?

CEDAR RAPIDS. Door swung violently open about 2 A. M. From private advice we learn that this was probably not due to an earthquake.

On reviewing these data for the times of occurrence of the earthquake, we at once observe how much they vary. This is, of course, largely due to the fact that it took the observers by surprise, and they did not think to look at their time-pieces at the instant the shock was felt. When it occurred to them to note the time, they were no longer able to tell the exact minute and so guessed—usually to the nearest five minutes, or even to the nearest half hour. The number of times that the time is given in minutes multiple of

five, as found in the preceding list, will show how general this method was. In addition to this time-pieces are usually incorrect and their reading cannot be trusted to nearer than a minute or two.

Another reason of the variation in the times given is probably due to there having been more than one earthquake, all occurring at about the same time.

The slight tremor noticed at two stations in Iowa seems to have been independent of those east of the Wabash and Lake Michigan. The time at least at Dubuque was perhaps the same, but we can hardly understand how, if it was one continuous earthquake, the tremor was not felt in any part of the populous region lying between Dubuque and Michigan City or Danville. That other independent shocks occurred is shown by the record at Angola, Ind., where three shocks were felt, the times of which seems to have been determined with rather more than usual precision. These times were 2:13, 2:31, and 2:53, and the shocks were separated by 18 and 22 minutes. These separate shocks may have been felt quite generally, and may thus account for some of the discrepancies. The separate shocks generally mentioned in the list as separated by only a few seconds were undoubtedly only distinct maxima of a single shock and may have been due to two distinct systems of waves (as longitudinal and transverse,) or to disturbances due to the refraction or reflection of the original vibrations. In every case they are to be looked on as parts of a single shock.

From the confusion due to imperfect observations, to errors, and to several sources of disturbance, it is hard to extract any systematic arrangements of the times, but if they be selected with care and judgment from the list, it appears.

1st. That the shock was earliest felt first south of Saginaw Bay in Michigan, in Central Ohio, northeast of Columbus, and from the vicinity of Dayton, Ohio to Switzerland County, Indiana. The time at which it was felt in these localities was about 2:11.

2nd. That between these three points the times were earlier than generally elsewhere;—at Detroit 2:13, at Cleveland 2:14, at Columbus, 2:14;—indicating that the points of early disturbance mentioned above were connected. If this is the case the 2:11 earthquake began along a line starting from near the head of Saginaw Bay and striking down to Central Ohio, then southwest to the southeastern corner of Indiana.

3rd. On the eastern side of this line concentric lines for the positions of the earthquake waves at 2:15 and 2:20 can be drawn

with fair agreement with the reported times, and these for 2:25 and upwards are indicated by London, Ont., Leetsdale, Penn., Wheeling and Parkersburg, W. Va. The wave seems to have propagated itself eastward without any general disturbance by other shocks. Its velocity of propagation in this direction was apparently 8 or 10 miles per minute, which is somewhat below the ordinary velocity of earthquake-waves and about the velocity of sound. Mr. Hitchcock at the "Junction" in Paulding Co., reports hearing the sound first, then feeling the ground move. This is west of the central line which we have traced, but the velocity was probably about the same in all directions.

5th. On the western side of the central line no parallel lines for 2:15, 2:20 etc. can be found, but along Northern Indiana and Northern Ohio from Angola to Archbold there are some early times grouped together, and from this region the times increase gradually and rather regularly as we go out. The line of 2:15 on the western side makes a slight bay in the southern part of the state, extending into Ohio, then turns its convexity westward and embraces Indianapolis and South Bend.

6th. In Michigan it is not practicable to define the western lines of 2:15 and 2:20, but Grand Rapids lies outside of them.

It seems, therefore, that we can define at least two distinct shocks, one originating about 2:10 along a line crossing Ohio and terminating in Indiana and Michigan; the other in Northeastern Indiana and Northwestern Ohio at about 2:13. In addition to these we have the Angola reports of 2:31 (which may be the shock from the earth) and 2:53. With the last may perhaps be associated some late hours given in the list. There were, besides, reports in the newspapers of shocks felt earlier in the day, but, without further evidence, these may be discredited.

The earthquake seems, therefore, to have been somewhat diffused with a long line of origin for the principal disturbance, and shorter ones or points for the minor ones. In this respect it agrees with previous earthquakes over the eastern United States and Canada, which have had generally a diffused character and an originating line rather than point. Instead of originating at a center, as is usually the case elsewhere, they seem to originate from an extensive tract, (probably a line) and instead of a single severe shock, we are apt to have several or many lighter ones.

The directions given for the progress of the wave are probably not very trustworthy. They sometimes differ at the same place

and time by 180°. As they were in every case but one, (Wooster, Ohio) determined only by the sensations and the direction in which suspended articles were swung, little reliance can be placed on them. They are found, however, to agree even better than might be expected with the direction as shown above by the times.

The other phenomena accompanying the earthquake require no special attention. People were nauseated and school-children frightened, but the damage done was insignificant. There is a notable absence of any premonitions shown by the lower animals or felt by human beings. In this case nothing of the sort has come under the eye of the writer though he has examined about 1000 accounts of the earthquake. The noise was quite generally heard and was usually described by comparing it to the muttering of distant thunder or the rumbling of a heavy wagon. The phenomena of all kinds were most notable over a band of territory stretching from Northern Indiana to the Panhandle of West Virginia.

CLIMATE AND HEALTH IN MICHIGAN.*

By HENRY B. BAKER, M. D., Lansing, Michigan.

Every one speaks of the weather and of the health in close connection, and yet few people realize how closely health is dependent upon weather and upon climate. To illustrate this, a diagram is here given, in which one curve represents the rise and fall of temperature in Michigan; the average for several stations for a series of six years (1877–82) being shown here by months, together with a curve of the rise and fall of sickness from diarrhœa (an average for the same six years), from which it may be seen that in that part of the year in which the temperature is high, there is a close correspondence between the two curves. In the same diagram is a line representing sickness in the same years from pneumonia (inflammation of the lungs), and it may be seen that if the temperature curve were reversed, that is, made to descend to represent a rise in temperature, the two curves would be very similar. Pneumonia occurs a little after the cold weather has begun, and continues after the weather has grown warm; hence, in a compilation by months, the rise or fall in the line representing sickness from pneumonia appears to be a month later than the corresponding fall or rise in the temperature line; in a compilation by weeks the interval between the two lines would probably be less. A similar remark may be made of the relation of the sickness from diarrhœa to temperature, substituting the words, "hot weather" for "cold weather."

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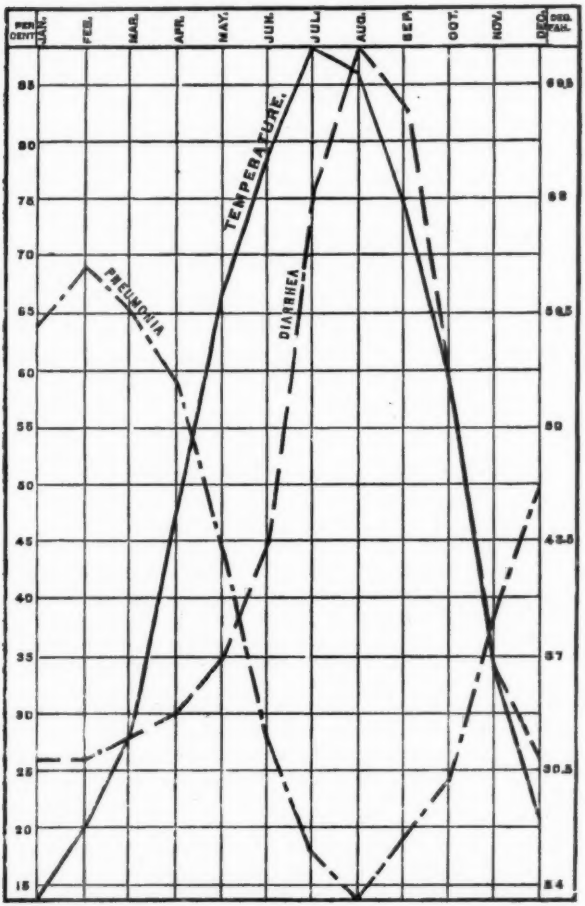
* Reprint from *Descriptive America*, August, 1884.

DIAGRAM.—Average Temperature, and Per Cent. of Weekly Reports stating presence of Diarrhœa and Pneumonia, in Michigan, 6 years, 1877—82.



For several years the Michigan State Board of Health has had a number of meteorological observers in different parts of the state, taking observations three times a day; and several of them are supplied with registering instruments which make continuous records. That Board has also had from many different parts of the state weekly reports of the sickness which has occurred, so that there is no state in the Union, and probably no such area in the world, concerning which,

the relations which the health of the inhabitants bears to the climate can be written about and studied with reference to the exact facts, so thoroughly as can be done for the State of Michigan.

Those elements of climate which are generally supposed to have the closest relations to health are:—

1. Temperature and its fluctuations
2. Humidity.
3. Rainfall.
4. Cloudiness (sunshine).
5. Winds.
6. Ozone.
7. Malaria, or marsh miasm.

The last-named, though usually least capable of scientific analysis, has been considered of more consequence than any of the others.

These elements of climate may be touched upon in the above-indicated order.

1. The extent of territory north and south is so great that there is a considerable difference between the temperature of the most northern and that of the most southern part of the state. What that difference is, and several other facts, can be well shown by such a table as Table No. 1.

TABLE 1.—*Latitude and Longitude, Elevation above Sea Level, and the Average Temperature, in* 1882, *at* 22 *Meteorological Stations in Michigan,—the names of the stations being arranged in order by latitude, highest first.*

LOCALITIES IN ORDER OF LATITUDE.—THOSE FARTHEST NORTH, FIRST	Latitude North.	Longitude West from Greenwich.	Altitude (Approximate) above Sea Level.—Feet.	Average Temperature, 1882. Degrees Fahr.
Marquette	46°33′	87°36′	638.07	42.28
Escanaba	45°46′	87°14′	594.693	42.76
Alpena	45°5′	83°28′	587.9	42.68
Traverse City	44°45′	85°40′	598.	45.13
Harrisville	44°39′	83°18′	.....	44.62
Reed City	43°44′	85°28′	1,016.	45.63
Otisville	43°13′	83°31′	820.	47.21
Grand Haven	43°5′	86°18′	595.3	48.18
Port Huron	42°58′	82°29′	600.	45.78
Thornville	42°55′	83°12′	975.	49.02
Lansing	42°44′	84°33′	900.	49.23
Hastings	42°40′	85°17′	750.	47.94
Washington	42°40′	83°	746.33	46.85
Winfield	42°30′	84°34′	.....	47 82
Detroit	42°20′	83°2′	602.6	51.20
Battle Creek	42°20′	85°11′	800.	50.20
Kalamazoo	42°18′	85°35′	975.	48.69
Ann Arbor	42°17′	83°44′	930.	47.31
Marshall	42°17′	84°58′	885.	49.58
Mendon	42°2′	85°29′	871.	48.91
Tecumseh	42°1′	83°57′	835.	48.06
Hillsdale	41°55′	84°34′	1,139.	47.70

The average temperature for several stations in Michigan, for the six years 1877–82), is stated by months, in Table No. 2, which is given below.

TABLE 2.—*Meteorological conditions in Michigan,—the temperature being stated in degrees Fahr.: the absolute humidity, in grains of vapor in each cubic foot of air; the relative humidity, in hundredths—complete saturation being 100; the rainfall in inches: the cloudiness in percent. of sky covered by clouds; the velocity of the wind in miles per hour; and the ozone, in degrees of a scale in which the maximum is 10.*

Meteorological Condition.	Annual Average.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Average Temperature*	47.61	23.42	27.30	32.49	45.14	57 84	65.42	71.73	69.89	62.41	52.07	35.88	27.72
Daily Range of Temperature†	17.71	16.17	17.33	16.17	19.52	21.34	19.80	19.77	19.15	18.46	17.74	14.55	12.58
Absolute Humidity*	3.57	1.52	1.67	1.97	2.81	4.07	5.30	6.27	6.10	5.12	3.90	2.32	1.81
Relative Humidity‡	.75	.81	.79	.76	.68	.66	.71	.72	.74	.75	.76	.79	.82
Inches of Rain and Melted Snow.*	38.67	1.89	2.37	2.97	2.92	3.26	4.29	3.72	3.79	3.59	3.82	3.49	2.65
Percent. of Cloudiness*	55	67	59	63	50	44	48	40	44	45	56	69	78
Velocity of wind, per Hour and Miles§	9.6	11.5	11.7	11.8	11 1	10.1	8.7	8.5	6.9	7.5	8.6	8.6	10.1
Ozone (during night)*	3.14	3.86	4.00	4.29	3.60	3.18	2.91	2.37	2.20	2.30	2.82	3.41	3.60

* Average for six years, 1877—82, at several stations in Michigan.
† Average for five years, 1878—82, at several stations in Michigan.
‡ Average for four years, 1879—82, at several stations in Michigan.
§ Average during the year 1882 by self-registering anemometers, at 8 stations in Michigan.

The author of the article on "Climate" in the latest edition of the Encyclopædia Britannica, after speaking of a region which he claims presents more sudden transitions of climate than any other portion of the globe, says (page 6, vol. VI.): "A direct contrast to this is offered by the United States to the east of the Mississippi, a region characterized by a remarkable uniformity in the distribution of its rainfall at all seasons, which, taken in connection with its temperature, affords climatic conditions admirably adapted for a vigorous growth of trees, and for the great staple products of argiculture." He might have added that for similar reasons the climate is also admirably adapted for the maintenance of vigorous health. So far as relates to the equability of the temperature, Michigan is the most favorably situated of these favored states, because of the great lakes which nearly surround the state except on its southern border, and which tend to still further equalize the temperature, by cooling the air in summer and warming it in winter, these being well-known effects of large bodies of water. The modifying effect on the summer temperature is perhaps most noticeable in June, which is a very delightful month in Michigan.

The average daily range of temperature in Michigan, as shown by self-registering thermometers, is shown in one line of Table 2. If computed from observations made only three times a day, instead of continuously, it would appear much less.

2. The absolute humidity of the atmosphere is now known to have close relations to healthfulness, as respects quite a number of diseases; a warm, moist atmosphere being favorable to health so far as regards the lungs and air-passages, and unfavorable to children and others liable to suffer from diarrhœa and diseases of the bowels and digestive organs. The curve in a diagram representing the absolute humidity in Michigan is very nearly the same as the curve representing the sickness reported from diarrhœa, from cholera-infantum, or from cholera-morbus; and as the quantity of moisture in the air is greatly dependent upon its temperature, increasing as the temperature rises, and decreasing as it falls, any cooling of the atmosphere in summer by the great lakes tends to lessen the actual humidity of the atmosphere at the very time of year when most beneficial, that is to say, when humidity is most harmful; on the other hand, any warming of the winter air by passing over the great lakes, tends to increase its humidity at the very time of year when most needed, that is to say, when dryness of the air seems to be most harmful;* because the investigations which have been carried on in this state during the past ten years have proved that the sickness from bronchitis, and from inflammation of the lungs increases immediately after the occurrence of cold, dry air, and decreases immediately after the occurrence of warm, moist air; the curves for these diseases being somewhat like and following the reversed curve for absolute humidity.

3. Although the relative humidity has not been proved to have very close relations to health, the facts respecting it may as well be stated, especially as meteorologists have quite generally supposed that it must have great influence. It will be seen from the fourth line in Table 2 that in Michigan the air is not more than three-fourths saturated in any month in summer, when, as we now know, actual humidity of the air is unfavorable; and that the air is more than three-fourths saturated in every month of winter, when, as we now know,

* The writer knows very well that in England it is claimed that it is the cold *moist* air which is most coincident with diseases of the lungs and air-passages; but it must be understood that when those who have studied the subject in England speak of humidity, they do not mean the *actual* humidity, but, on the contrary, they refer to the *relative* humidity or per cent. of saturation, the curve for which is very different from the curve of absolute humidity.

a dry, cold air is unfavorable because of its influence in causing diseases of the air-passages. The line referred to is an average line for a period of years, and also an average for several stations; it therefore represents the state as a whole. If we were to examine the averages by months for each year, or for each station, exceptions would be found to the statement just made as to the per cent. of saturation of the air in summer and winter, but those statements are made with reference to the state considered as a whole.

4. A statement of the very favorable rain-fall in the United States east of the Mississippi was given when speaking of the temperature, but what the actual rain-fall in Michigan has been may be seen by the line in Table 2, where it is stated.

5. The average cloudiness is shown by a line in Table 2.

6. The average velocity of the wind is shown in Table 2, and no special remarks are needed, except that tornadoes are not common in Michigan.

7. The ozone, by night observations, is shown in the table. It may be remarked in passing that the curve of the night ozone by months, when reversed, is very nearly the curve for the average sickness reported from remittent fever.

FROM WHAT DISEASE IS THERE MOST SICKNESS?

If it be asked, From what disease is there most sickness in Michigan? the reply is, that the reports show it to be intermittent fever. If we now turn to the mortality statistics, we find that the deaths from intermittent fever are so few as to be insignificant, compared with most other causes of death. In Michigan, as in most healthful states, the greatest number of deaths are from consumption; but the deaths from that disease are not of so large a proportion of its inhabitants as in most states—not so large, for instance (according to the United States Census of 1870), as they were in Pennsylvania or in Louisiana.

8. *Malaria.*—A few years since Prof. Kedzie, ex-President of the Michigan State Board of Health, and ex-President of the American Public Health Association, collected from the leading physicians of the state their opinions, and the facts upon which they were based, respecting the occurrence of malarial diseases, and the decrease in such diseases within their knowledge. The evidence was conclusive that there had been a very great reduction, and that it was probably due to the clearing of the land, and consequent drying and warming of the soil, which has been supplemented in many parts of the state by extensive drainage and under-drainage, the reclaiming of marshes, and the clearing out of swamps. Improvements in this direction are still rapidly progressing. The Michigan of to-day is no longer the Michigan of the early days of its settlement. The motto of the state—If you seek a beautiful peninsula, look about you—is now generally acknowledged to be quite applicable. The upper peninsula has its picturesque scenery and its great mineral wealth; the lower peninsula is a delightful agricultural region, thickly dotted by beautiful lakes, and traversed by pleasant streams of running water. Detroit, the beautiful City of the Straits, by the side of one of the noblest rivers in this country, is a city of which any state may well be proud. There are very many other places in the state which have a high reputation both for health and attractive scenery.

WHAT CLIMATIC CONDITION IS MOST TO BE FEARED?

The author of "Atmosphere" in the Encyclopædia Britannica, referring probably to the total deaths from all causes, says (page 30, vol. condition III.):

"The curve of mortality for London, England, if mere infants be excepted, has thus an inverse relation to the temperature, rising as the temperature falls, and falling as the temperature rises. On the other hand, in Victoria, Australia, where

the summers are hotter and the winters milder, the curves of mortality and temperature are directly related to each other—mortality and temperature rising and falling together; the reason being that in Victoria deaths from bowel complaints are much greater, and those from diseases of the respiratory organs much less than in London.

The time of year of greatest danger to health and to life in Michigan may be seen by the following tabular arrangement of months, and the remarks appended:

Months arranged in order of the most sickness and most deaths—those named first in which there was most sickness or most deaths.

Order.	STATE OF MICHIGAN.		PROVINCE OF ONTARIO.	
	Sickness. (1877—82.)	Deaths.* (1871—82.)	Sickness. (Oct. 1882 to Sept. 1883.)	Deaths. Five years.
1	September	August	March	March
2	August	September	April	April
3	October	April	May	August
4	February	March	February	February
5	January	October	September	September
6	March	May	August	May
7	November	July	January	January
8	December	December	July	July
9	April	February	October	October
10	July	November	June	December
11	May	June	December	November
12	June	January	November	June

* Corrected for greater proportion of omissions in enumeration in early part of the year.

By the table above, it will be seen that the months in which there is most sickness in Michigan are September, August, October, etc.

And the diseases from which there is most sickness in Michigan in August, September and October are:—diarrhœa and other diseases now known to have close relations to a high temperature, and the autumnal fevers,—intermittent, remittent, typho-malarial, and typhoid—which seems to be in some way so related to high temperature that they generally follow it. It thus appears that the direction in which to look for a *perfect* climate is toward one slightly colder than the average of that of Michigan, at least in the summer months.

The only other sickness-statistics now being collected in this country are those of the province of Ontario; and these have not been collected for a time sufficiently long to enable one to judge well of the relative healthfulness there during the several months;—but so far as one year's statistics are any guide, it appears that there is most sickness there in the months, March, April, May, etc. as shown in the foregoing tabular arrangement of months; the data for that part of it relating to Ontario being supplied by the Ontario report of the provincial Board of Health for 1883. So that one seeking a colder climate than the average in Michigan must stop short of one as cold as the average in Ontario, because there he would already have found one where the most sickness occurs in, or directly following, the cold season of the year.

In the search for a perfect climate, it must be remembered, also, that equability is of some consequence, and that there are few states so favorably situated in that respect as Michigan. There is nothing published which shows the comparative death-rates recently in the several states, and registration of vital statistics in Canada is so recent that no complete returns of deaths are yet received. Perhaps the best that can be done is to see how the death-rate in Michigan compared with that in other states at the time of the U. S. Census of 1870. Arranged in order, those in which the death-rate was least being placed first, the states and territories and the number of deaths to each 1,000 inhabitants are as follws:

Idaho, 3.3; Oregon, 6.9; Dakota, 7.1; Minnesota, 8.0; Wyoming Ter., 8.1; Nebraska, 8.1; Iowa, 8.1; Montana, 9.0; West Virginia, 9.1; Washington Ter., 9.3; Colorado, 9.4. Michigan, 9.4; Wisconsin 9.4; North Carolina, 9.8; Utah, 10.3; Indiana, 10.5; South Carolina. 10.5; Vermont, 10.7; Alabama, 10.8; Kentucky, 10,9; Mississippi, 11.1; Ohio, 11.1; Tennessee, 11.3; Georgia, 11.5; New Jersey, 11.7; Florida, 12.1; Maine, 12.3; Maryland, 12.4; Virginia, 12.4; Delaware, 12.5; Kansas, 12.5, Arkansas, 12.6; Connecticut, 12.6: Rhode Island, 12.6; New Mexico, 12.8; Illinois, 13.3; New Hampshire, 13.5; Texas 13.7; Nevada, 14.5; Pennsylvania, 14.9; District Columbia, 15.3; New York, 15.8; California, 16.1; Missouri, 16.3; Massachusetts, 17.7. Louisaina, 20.0; Arizona, 26,.1. The average for the Unied States was 12.8.

These statistics only approximate to the truth, not all deaths being reported in any state, and though usually comparable one state with another, this is not true with respect to Massachusetts, in which the system of collecting the records of deaths makes the proportion of the deaths whieh were returned in the census larger than in many other states. Some allowance on this account should be made for the states of Vermont and Rhode Island. One more important fact should be remembered, namely that such new states and territories as Idaho, Dakota and Wyoming contain very few inhabitants at those young or old ages at which the death-rate is greatest; nearly all being in middle life, at which ages few die. Yet it will be seen that Michigan, though a state which has been settled long enough to have a fair proportion of both old and young among its inhabitants, is found very closely approaching the very newest of the states and territories in the smallness of its death-rate, which according to the census was only 9.4 in 1000 inhabitants during the year. (More perfect methods than were adopted by the census make it probable that the actual death-rate was about 17.0 per thousand per annum; but these figures should not be used for comparison with the other states, because it is fair to assume that similar methods of perfecting their vital statistics would have increased their apparent death-rate in a similar proportion.)

Probably it will be found that, after the drainage and other improvements of the soil which occur with the cultivation, and which do so much to favorably modify the local climate shall have continued for a time as they are now progressing, there, the climate in the northern portion of the lower peninsula of Michigan will be found to be about as near perfect as any in this country.

Total number of deaths returned as having occurred in Michigan in each of the 10 years 1873—1882; the number of deaths each year from Consumption, Diarrhœa, Intermittent fever, and Pneumonia; the per cent. of deaths from each of these diseases to the deaths from all causes; the average number of deaths for 10 years, and the average per cent. of deaths from each specified cause to the deaths from all causes, for the same period.

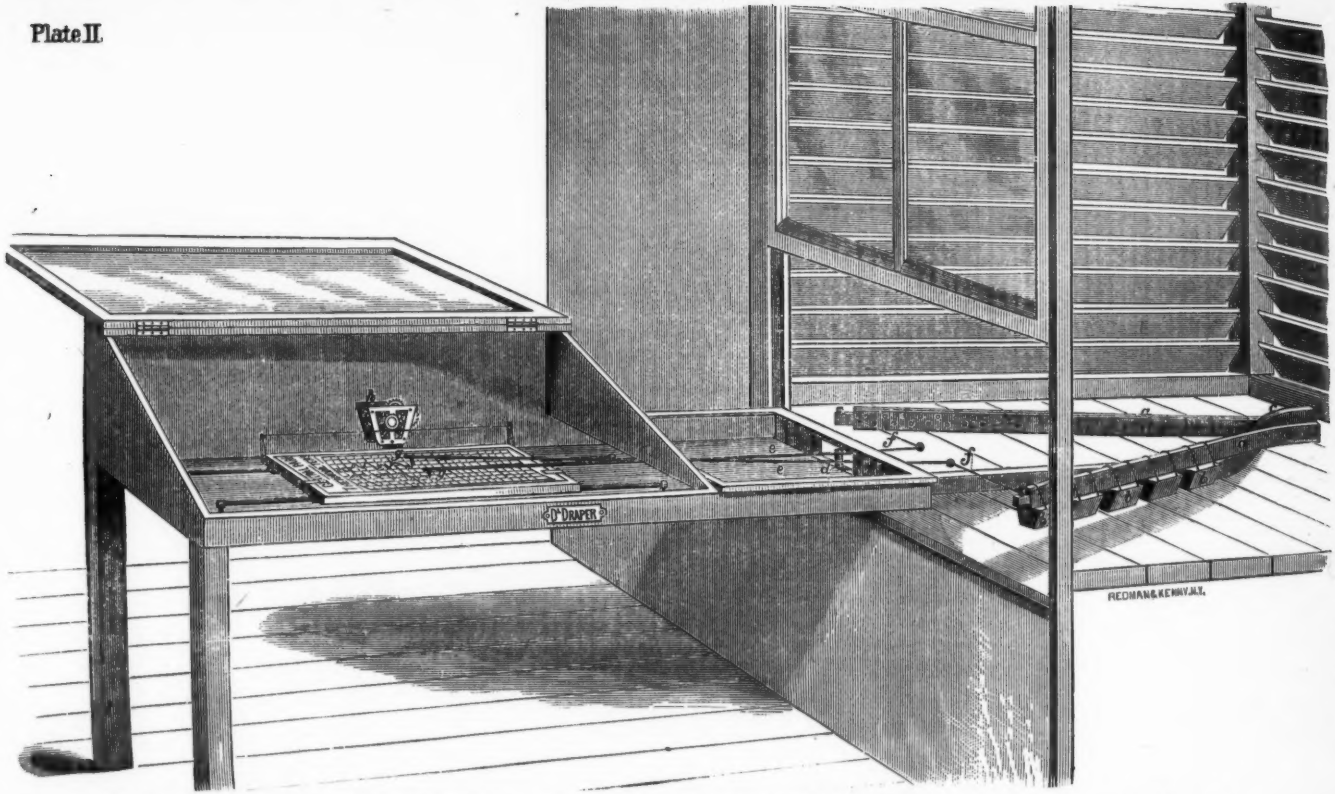
Deaths from:		Average Annually 1873 to 1882 inclusive.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.
All causes	No.	13,299	14,253	12,500	11,990	12,576	12,919	12,766	14,407	16,102	19,28[illegible]	[illegible]
Consumption	No.	1,567	1,447	1,392	1,479	1,530	1,664	1,641	1,683	1,829	1,954	1,904
	Per ct.	11.96	10.15	11.14	12.34	12.64	12.88	12.85	11.66	11.36	10.16	10.98
Diarrhœa	No.	317	383	380	283	304	290	173	226	310	501	253
	Per ct.	2.43	2.69	3.04	2.36	2.42	2.24	1.35	1.57	1.93	2.60	1.57
Intermittent fever	No.	48	73	62	39	36	53	47	46	32	45	34
	Per ct.	.37	.51	.50	.33	.29	.41	.37	.32	.20	.23	.21
Pneumonia	No.	624	706	800	743	627	665	462	701	812	865	725
	Per ct.	4.69	4.95	6.40	6.20	4.99	5.60	3.62	4.87	5.04	4.48	4.47

DR. DRAPER'S THERMOMETERS

Pencil Thermometers (Dry and Wet.)

After experimenting with many different substances, such as brass and glass, hard rubber and glass, I eventually found that iron and zinc gave thermometer bars most suitable for meteorological purposes; they may be graduated from zero to the boiling of water without changing their condition. After many hundred trials it was found that when two strips of zinc were riveted to one of iron, the best results are obtained.

Plate II.



DRAPER'S PENCIL THERMOMETERS. (DRY AND WET.)

DESCRIPTION OF INSTRUMENT.

The portion of the instrument represented as projecting out of a window towards the north, consists of the dry and wet thermometer bars fastened to the same iron frame, the loose ends pointing towards the room, and connected by light link rods to the short ends of the two levers, which carry on their long ends ink pencils that mark the fluctuations on the register sheet.

The curved bars, *a a*, consist of two strips of zinc, each $\frac{1}{32}$ of an inch thick by 1 inch wide and 20 inches long, riveted on the same side to a similar single piece of iron. On warming this bar it curves from the zinc side, that metal being more expansible than iron. If cooled, the reverse takes place. On the right hand bar there are several small troughs, *b b b*, with cotton threads to convey moisture to it. This part of the apparatus represents a wet-bulb thermometer. Several troughs are used, so that when the cotton becomes frozen in cold weather it will not resist the bending of the bar, as would be the case if there were only a single one. These bars are firmly fastened to the iron bar, *c*, which returns to the case in the room; on this is raised a pillar, *d*, which acts as a fulcrum to the slender brass levers, *e e*, one end of each lever being fastened by the connecting links, *f f*, to the loose ends of the compound bars, *a a*. On the other ends of the levers are ink pencils, *g g*, one containing red, the other blue ink; these mark on the register drawn by the clock, *h*, towards the left hand, the movements of the metallic bars, as is depicted on the register sheet, which is divided into degrees by the straight lines, and into hours by the curved lines.

The sensitiveness of these bars to sudden changes compares very favorably with the readings of the standard thermometer. This is not more than might be expected from the large surfaces they present to the weather.

Sun Thermometer.

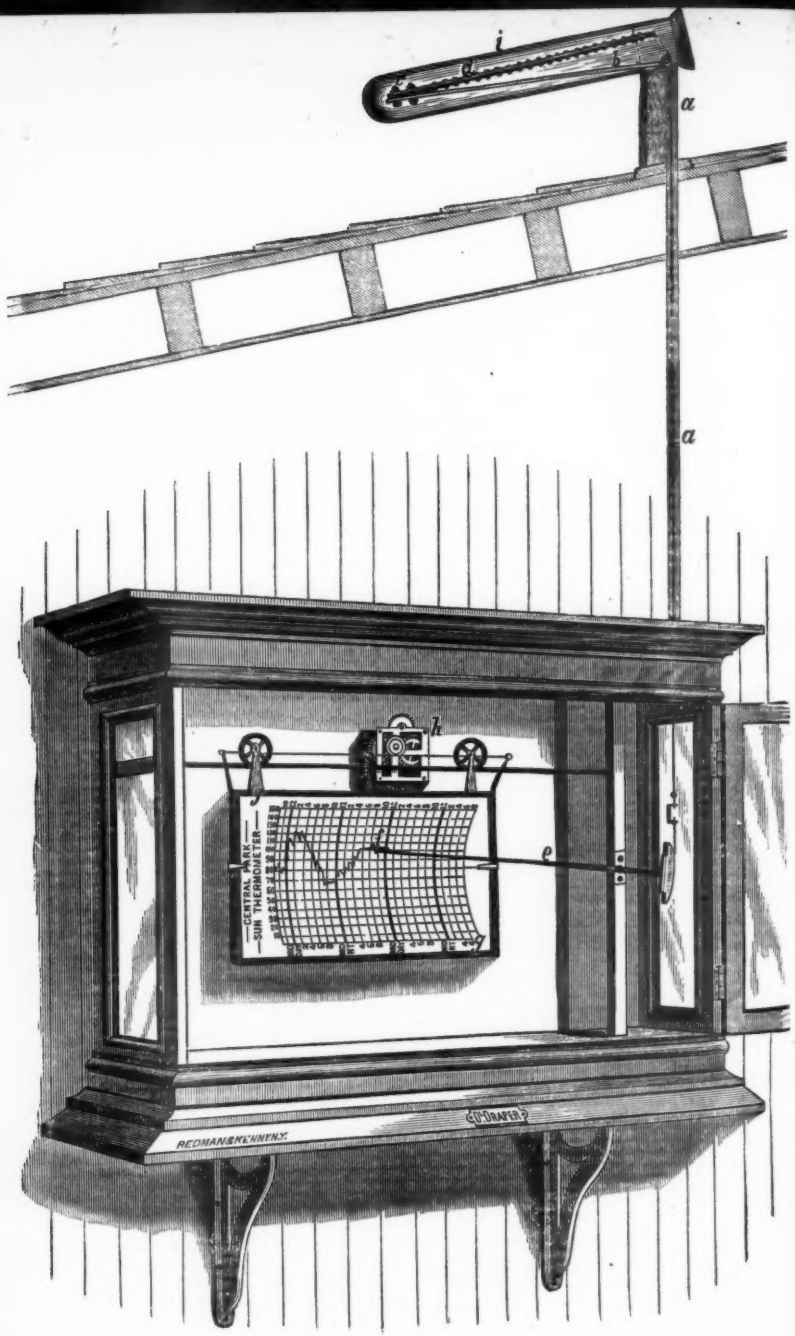
This instrument is constructed on the same principle as the dry-bulb thermometer, except that the metallic bar is inclosed in a glass shade, 4 inches in diameter and 20 inches long, mounted two feet above the roof, and exposed to the direct rays of the sun. There is no vacuum in the glass shade; it only serves to keep the wind and rain from the bar. The bar is connected by a wire to a lever multiplying four times in the room below, in which is placed a case with its clock, lever, register sheet, etc.

DESCRIPTION OF INSTRUMENT.

Extending from the instrument in the room through the roof is an iron pipe, *a*. On its upper end it carries an iron bar, *b*, to which is fastened firmly, at *c*, the metallic thermometer bar, *d*; from the loose end of this bar a fine wire descends over a guide pulley down the inside of the pipe to the lever, *e*, in the case in the room below. On the long end of the lever is an ink pencil, *f*, that records the motions of the thermometer bar on the register sheet, *g g*, which is fastened by means of two small clamps to the board that is carried sideways by the clock, *h*. Over the metallic thermometer bar above the roof is a glass shade, *i*, protecting it from the weather.

On the register paper, *g g*, are shown the fluctuations for the day. In this instance many clouds have passed between the sun and instrument. If the curve had been without oscillations it would show that the day had been clear.

DRAPER'S PENCIL THERMOMETERS. (DRY AND WET.)



DRAPER'S

SUN THERMOMETER.

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AN ILLUSTRATED MONTHLY

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LITERARY NOTES.

PERIODICALS.

Meteorologische Zeitschrift, redigirt von Dr. W. Köppen. October, 1884.

(29) R. BÖRNSTEIN: Ueber den von Nipher vorgeschlagenen Schutztrichter für Regenmesser. 381–387.

Accepting the satisfactory conclusion that variation of rain collected in gauges at different altitudes depends on the wind, Börnstein experimented with a rain-gauge of Nipher's pattern, (v. Omer Ossoc Proe,, 1878) and with another on which the wind-funnel was inverted, so as to exaggerate instead of correcting the effect of air-currents. The difference in amount of rain thus collected was greatest in light rains with strong wind. Nipher's suggestion is regarded as lessening the error of ordinary gauges. The experiments would have been improved if they had included measures from an ordinary gauge.

(30) A. WINKELMANN: Zum Studium der Regenfälle mit Rücksicht auf die Regenprognosen. 387–392.

A consideration of the agreement of local weather at various stations with the general forecasts for the district that includes them. For thirteen stations in Württemberg, 85.5% of days show full agreement; general rains are 4.8 times heavier than local. There is no mention of the physical condition by which the local rains are to be foreseen.

(31) NEUMAYER: Die Bedeutung synoptischer Studien im Südatlantischen Ocean. 393–396.

The 'Deutshe Seewarte,' at Hamburg, is undertaking the preparation of daily synoptic charts of the South Atlantic, for the period from Aug. 1, 1882, to Aug. 31, 1883; the same period is covered by the international

polar observations, and by the daily charts in preparation for the North Atlantic by the English Meteorolgoical Office. The charts will be prepared for 8 A. M. and 8 P. M.; and average of 59 observations is already collected for every chart.

(32) DEUTSCHE SEEWARTE: Eine rationelle Methode zur Prüfung In Wetterprognosen. 397–404. (From the *Monatliche Uebersicht der Witterung.*)

The necessity of comparing the percentage of successful predictions with the percentage of probable accidental success. For example, the prediction of "light to moderate winds" steadily all summer round, give nearly 100% of success (for Hamburg); again the occurrence of ten local storms in thirty-two predictions of the same (31%) is to be regarded as satisfactory, because accidental prediction would give only 22%. Tables illustrating a proposed "rational" method of testing forecasts are given for June, July and August, 1884.

(33) L. WEBER: Ein merkwürdiger. .405-407.

(34) H. HOFFMANN: Beobachtungen über thermische Vegetations-Konstanten. The continued sum of daily maxima of a sun themometer, from the first blossoming to the first ripening of fruit for a number of plants is shown to have corresponding values at Giessen and Upsala.

(35) VEREINSANCHRICHTER. 411-.415.

The first annual meeting of the German Meteorol. Society was held in Magdeburg, Sept. 19, 20, 1884. The officers are: president, Neumayer; vice president, v. Bezold; Editor, Köppen; von Bebber and Sprung, secretaries. Papers were read by von Bebber.

Einige Bemerkungen über meine Weltertypen; Neumayer as above: Hoppe, Ueber atmosph. and Gewitter elektricitat; Köppen, Principien der Vertheilung meteorologischer Stationen, and Ueber Barometerschwankungen beim Gewitter (all these will appear in the society's *Zeitschrift*); Kiessling, Die Diffractions Erscheinungen und die Dämmerungsphänomena (mist experimenter); Münter, Ueber die Ursachen des Windes.

(36) **E. de Freudenreich.** Recherches sur les organismes vivants de l'air des hautes altitudes. Arch des Science (Genève), xii, 1884, 365–387.

Very few microbes discovered in the upper Alps, where the organic purity of the air approaches that over the sea.

(37) **Annalen der Hydrographie und Maritimen Meteorologie.** Organ des Hydrographischen Amtes und Deutschen Seewarte. Herausgegeben von dem Hydrographischen Amt der Admiralittät. xi, 1884 (November). Berlin.

(38) *Zwei Stürme im Nördlichen Stillen Ocean in der Nähe der Küste von Mexico,* p. 624–625 (Mittheilung der Deutschen Seewarte).

Brief abstract of German logs giving evidence of storms on Sept. 21–22, and Oct. 3–4, 1883; both moved northerly, although in relatively low latitudes.

(39) *Vergleichende Uebersicht der Witterung des Monats August, 1884, in Nordamerika und Centraeuropa.* (Mittheilung der Deutschen Seewarte), p. 649–650.

A brief comparative statement prepared every month, based on our "Monthly Weather Review" and the German "Uebersicht der Witterung," under such headings as barometric minima and maxima, mean barometer, winds, rain, and temperature.

(40) **H. Kayser:** Ueber Blitzphotographie. Berlin Akad. Wiss. Sitzungsbĕr., xlviii, 1884, 1119–1122, with two plates.

Excellent photographic view of a lightning flash, taken in a rain storm July 16, 1884, at a distance of about 300 met. The flash is seen to be composed of four parallel irregular lines; the first is broadest, and, when magnified, shows a peculiar transverse structure of parallel bright and darker lines; the other three are finer. The main flash gave out numerous sub-dividing branches which could be traced to sixty different endings. The flash was thought to be composed of four successive or alternating sparks, the first of which vaporized the rain-drops it encountered, thus perhaps giving rise to the transverse structure, and forming a path of least resistance that the other sparks followed. The displacement of the parallel lines is thought to arise from the bodily shifting of this path by the motion of the air; knowing the velocity of the wind at the time and the scale of the photograph, it was calculated that the intervals between the sparks were 0.36, 0.04 and 0.07 seconds. [Amateur photographers have an interesting field for work in this study. Rood's observations (*Amer. Jour. Sc.*, v, 1873, 163) are of interest in the same connection].

W. M. D.

Symons' Monthly Meteorological Magazine. September to December 1884.

(41) *On the rainfall of Japan*, p. 123—125. Based on J. J. Rein's "*Japan.*"

(42) *A heavy Indian rain-fall*, pp. 123—125. Mr. A. M. Pearson describes the course and history of the cyclone to which were due the heavy rain of July 1, 1883, and the subsequent disastrous floods.

(43) *Meteorology at the International Health Exhibition*, pp. 125—127, 133—135.

(44) *Climatological Table for the British Empire.* Jan. 1884, p. 128; year 1883, p. 142; Feb. 1884, p. 144; March, p. 175; April, p. 176.

(45) *Tables of Rain-fall and Meteorological Notes*, August 1884, pp. 129—132; September, 145–148; October, pp. 161–164; November, pp. 177–180.

(46) *Heavy Rain during gale of October, 13, 1881*, p. 141. Mr. Thos. S. Stooke communicates a record of a rain-fall of 5.6 inches in 16 hours.

(47) *On the Climate of the British Empire during 1883*, p. 143.

(48) *A Tornado at Ely*, p. 160. Mr. J. H. White communicates a report of a small tornado on Aug. 31. The tornado cloud is described as a "pillar of white smoke" moving from southwest to northeast, and destroying everything in its path.

(49) *The Thunder-storms of 1884*, pp. 117–122, 135–140, 149–159. A long catalogue of thunder-storms extending from July 4 to Sept. 21, giving the reported loss of life and property. A summary of these reports presents the following totals: 35 persons killed, 91 injured; destruction of property, £10,000. The geographical distribution, ignition by lightning and kind of trees destroyed are discussed.

(50) *Another high level station*, p. 164. Mr. Clement Wragge has established a station on Mount Lofty, about ten miles from Adelaide, South Australia, and about 2200 feet high.

(51) *In Memoriam—Charles Clouston, LL.D., L. R. C. S., Edin*, pp. 165-167. The long series of observations made by Dr. Clouston, at Sandwick, forms an important contribution to meteorology; of especial value are the continuous records of the direction and force of the wind for 22 years.

(52) *Heavy Rain in the northwest of Scotland*, pp. 167–168.

(53) *The Meteorological Observatory of the "Magdeburg News"*, pp. 169–171.

(54) V. RAULIN; *Distribution of Rain in Ceylon during the Decade*, 1871–80, pp. 171–173. The island is divided into 6 régimes according to the character of the seasonal rainfall. (An

accompanying map is prepared by the editor).

(55) *Royal Meteorological Society*, p. 174.

(56) *The Brocken Spectre in Scotland*, p. 180.

G. E. C.

Quarterly Journal of the Royal Meteorological Society. Vol. X, No. 51, July, 1884.

(57) ROBERT H. SCOTT: Brief notes on the history of thermometers, pp. 167-172. The invention of the thermometer is put back to about 1587.

(58) HON. RALPH ABERCROMBY: On the origin and course of the squall which capsized H. M. S. Eurydice, March 24, 1878, pp. 172–183. With the data obtained from the international charts issued by the U. S. Signal Service, the author describes (1) the general condition of the meteorology of the northern hemisphere for the four days, March 21st to 25th; (2) the synoptic conditions of the complicated weather system on March 24th; (3) the sequence of weather observed at different stations during the day; and lastly discusses the connection of the whole. The squall was associated not with a primary cyclone, but with what is classed as a "V-shaped secondary," so called because the isobars run into a point like the letter V. The characteristics of different types are described.

(59) C. E. PEEK: Weather forecasts for October, November and December, 1883, pp. 183–187. Tables are presented giving the forecasts of the Meteorological Office that were verified or partly verified by the weather actually experienced at Rousdon, Devon.

(60) W. F. STANLEY: On certain effects which may have been produced in the atmosphere by floating particles of volcanic matter from the eruption of Krakatoa, pp. 187–195. The author presents arguments to show that the peculiar optical phenomena of 1883 and 1884, witnessed over the globe, must be due to particles of solid matter and not to gases, if they can be attributed in any way to volcanic eruptions. An analysis of volcanic dust from Krakatoa is given, together with diagrams of the particles. Two types of particles found in the dust are considered to be especially susceptible of indefinite suspension in the atmosphere, and to possess important optical properties —one type acting as perfect refractors of the red rays of the spectrum, the second type acting as reflectors.

(61) *Fifth Annual Exhibition of Instruments*, pp. 196–204.

(62) CAPT. J. W. C. MATYR: Waterspouts and their formation, pp. 204–205. Description of a waterspout on December 7, 1883, witnessed at a distance of 200 yards.

(63) *Atlantic Weather Maps*, p. 205. An early suggestion of ocean maps is found in a letter by Mr. F. Beaufort, dated September 11, 1833.

(64) *Rainfall in South Australia*, p. 206. Extract from report of Mr. C. Todd for 1881.

G. E. C.

BOOKS, ETC.

(65) **Element of Meteorology for Schools and Households.** By Pliny Earle Chase, L. L. D., Professor of Philosophy in Harver college (Penna.). Philadelphia, Porter and Coats. (no date on title page, but copyright in 1884.) Part I. Practical instructions. Part II, Principles and Scholia. 2 vols. 12°, 128 and 256 p.

It is well that scholars should feel individuality rather than depend entirely on text-books; but the impress of personality is carried too far in Professor Chase's Elements of Meteorology to warrant its being recommended as a manual for general use. The author desires that his book should contain easy and interesting object-lessons in practical meteorology for children between eight and twelve years of age; 2°, a

repository of materials for similar lessons, or for regular study, in classes of older scholars; 4°, a complete introduction to more advanced and exhaustive treatises; 5°, a summary of the results reached by Abbe, Blasins, Buchan, Caper, Chase, Fearel, Glaisher, Ley, Loomis, Scott, and the U. S. Sigal Service Bureau; 7°, a presentation of the most obvious dynamic influences of the moon on the weather as a guide to forecasts a month or more in advance, and many other topics. It is regretable that this desire is not more fully satisfied. The first part cannot be regarded as a suitable text-book for common schools; it is not simple or explanatory enough; its chapters are neither systematic nor compendious; its treatment is illogical and fragmentary; it by no means represents the present stand of meteorology. For the same reasons, it cannot be regarded as a "complete introduction" to more advanced works. The absence of mention of German and French meteorologists is not counterbalanced by quotations from Blasins and Caper. Under the heading of Storms, we read (pt. ii, p, 111, 112) that "Espy thought that the storm-winds blow inward toward a central line of minimum pressure, which is generally of great length from north to south, and moves side foremost toward the east," and that Blasin showed that the line of meeting between the warm and cold currents which give rise to storms must generally be inclined to the horizon, the warmer current flowing obliquely upward, and the cold current obliquely downward." It is hardly exact to close a series of paragraphs, that includes the above quotations, with the statement (p. 118) that "all of these laws have been fully tested and confirmed by the observations of the Signal Service Bureau, and by Loomis' Discussion of American meteorology."

Lunar control of the weather is one of the fundamental principles of the book. Ten of fifty-two "lunar proverbs" end with (pt. I, p. 99):—"If the new moon, first quarter, full moon, or last quarter occur between —(Summer)—12 and 2 A. M., fair, 2 and 4 A. M., cold and showers." etc., etc. This is "said to be the result of many years' actual observations, and it represents the action of the moon upon the regular daily barometric tides. It is, therefore, worthy of special study as a help in determining the character of the local disturbance of the moon" (p. 100). In view to Mr. Scott's recent utterance at a meteorological conference on the difficulty of eradicating the popular belief in the moon's control over the weather, we must suppose that, at least, a share of his recent investigations are not presented in these elements.

As to the "cumulative evidence of the far reaching influence of harmonic waves," we say nothing, being free from knowledge of these matters. But we protest against the astounding statements made in Capen's "Astronomic Science of the Weather," which seem to have the author's approval, as they are quoted without demur in Appendix C, pt. I. Here is a sample: "During the passage of some of the larger cold aërial valleys, troughs, or 'dips,' as they may be properly termed—*i. e.*, the cold intervals between the waves—which last, being lens-like, are always heat-producing, the sudden superinduction of the terrible cold of the upper regions, often over miles in extent, results in the production of an immense vacuum, the mechanical action of which is so vast and irresistible as to lift from the surface of the earth the largest trees, animals, and even buildings into the air, and large bodies of water from the surface of rivers, lakes and seas in the form of water spouts" (p. 116). It is

depressing to find such absurdity as this presented without a word of warning, and offered to the teachers in our common schools alongside of abstracts from Ferrel, Loomis and Ley.

Professor Chase is evidently an ardent observer as well as a rapt theorizer; his recommendation that practical weather studies should be undertaken in our schools and the emphasis he gives to the value of the general and local weather indications of the Signal Office are redeeming features of his book; but the book as a whole is very disappointing.

W. M. D.

(66) **Magnetical and Meteorological Observations** *made at the government observatory,* **Bombay,** *in the years 1879 to 1882, under the superintendence of Charles Chambers, Esq., F. R. S., and F. Chambers, Esq., together with appendices containing accounts of magnetic researches, embracing observations extending over a period of thirty-seven years. Printed by order of her Majesty's government. fol. Bombay, government central press, 1883.*

8, xx, 56, 27 pp. Appendix separately bound contains xiv, 241 pages and 36 plates containing 1050 figures.

As is well known to meteorologists the government observatory at Bombay is one of some fifteen or sixteen similar establishments founded by Great Britain at home and in her various colonies. Its establishment, like that of many others of the first class, especially those in Germany and Rus-ia, dates from the magnetic revival aroused by the researches of the great Gauss in the third decade of the present century. When Gauss' remarkable theory of terrestrial magnetism was first published, a most unexpected conclusion found to flow from it was that the greatest intensity of the terrestrial magnetic force was exhibited *not* at the magnetic poles, but at other points which, for distinction, are called *dynamic* poles. The absence of reliable information by which to test this theory was thus forced into startling prominence, and the Magnetic Union was the result; a union which was entered into with especial enthusiasm and liberality by the two governments, Russia and Great Britain; governments whose extended dependencies and liberality for this work enabled magnetical and meteorological observatories of the first class to be established at points scattered in all parts of the world. Russia's observatories extended from St. Petersburg to the Caucasus, and thence eastward through her vast domains to the confines of the Pacific; then crossed the sea to her most distant outpost in her American colony. Thus was founded in 1842 the old observatory at Sitka, in Russian America then, in Alaska now; Great Britain also scattered her observatories as widely as her domain, in India, in Australia, at St. Helena and "the Cape." The prime incentive in these establishments was the study of magnetism, but meteorology even at the outset was attended to with no less zeal. It will be noticed that the publications are entitled Magnetical and Meteorological observations, and not Meteorological and Magnetical, an order which was probably *not* accidental.

When these observations were established we had no magnetographs. Eye observations alone were available, and in many of these establishments reliefs of observers kept watch day and night, and every hour recorded the instrumental readings.

In 1859 Mr. Balfour Stewart made his report to the British Association for the Advancement of Science on the construction and management of a set of self recording magnetic

instruments. This account together with its supplement, applies to the magnetographs of the Colába Observatory, as the Bombay establishment, on Colába Island, is called.

The volume before us is the 23d of a series entitled, "Bombay Magnetical and Meteorological Observations," which series covers the period from 1845 to 1882. The present volume covers the 4 years 1879—1882, and the greater part of its space is devoted to magnetism.

The entire make up of the volume, its contents and its arrangement are on a grand scale; its great folio pages, 9½ by 13½ inches, its very coarse clear English type, its thousands, nay, hundreds of thousands of figures from the font most esteemed by all users of tables; its smooth, heavy, delicate buff paper, and its wide margins all testify to a lavish support and a cultivated taste. The publication is thus in keeping with the observations themselves.

Where all is so well done as here, the task of the reviewer is a very simple one, and it is only necessary to glean out some leading facts and results for the benefit of those whose time or opportunity deprives them of the pleasure of a personal examination of the volume.

The Colába observatory at Bombay India, founded in 1841 consists of four buildings, (one underground) and employs 13 persons as observers, assistants and computers. It i wholly devoted to magnetism, and meteorology, the astronomical part having reference merely to obtaining correct time. Certain eye observations commenced years ago, are still continued but are considered to be merely subsidiary to the registrations by the self recording instruments, which are

1. Magnetographs;
2. Barograph;
3. Thermograph;
4. Pluviograph;
5. Anemograph.

The eye observations are made at 6 and 10 A. M., and at 2, 4, and 10 P. M. Bombay civil M. T.

Basing our statements on the 4 years observations of the volume, the mean annual atmospheric pressure at the station (37 feet above the sea) is 29.82; mean annual temperature of the air, 80° F, and mean annual rainfall 72 inches. The range of temperature is very small, the absolute maximum and minimum being 96°.5 F. and 60°.4 F. respectively. The greatest range of temperature in any one month was 27° F.

If the mean temperature for any day be taken to be the mean derived from 24 hourly observations, then the warmest day in the 4 years had a temperature of 87°.5 F. and the coldest 67°-6 F. and the mean annual range is less than 16° F.

The mean *daily* range is presumably small, nevertheless we regret its absence from the tables before us.

From the middle of October to the middle of the following May, practically no rain falls, and during the remainder of the year the average is excessive, being some 11 or 12 inches per month. This precipitation is measured by three gauges, one 4½ feet, the second 28, and the third 46 feet above the ground; the highest gauge invariably catching the least, and the lowest gauge the greatest amount of rainfall. July is the windiest and wettest month the rainfall sometimes amounting to nearly one inch per day for the entire month.

As already indicated, this volume is devoted to terrestrial magnetism chiefly, and to meteorology rather incidentally; one-third of the volume itself, and all the appendices dealing with magnetism. The results of the absolute measures of the magnetic elements are published in the

form of full and satisfactory abstracts. The absolute declination and horizontal intensity are determined once each week, the absolute dip twice each week. The declination and dip are both small and the horizontal intensity large:

Declination,	0° 56′ E.	
Dip,	19 22	}
or	19 43	}

Hor. intensity, 8.105 in British units (foot—grain second).

How closely it is possible to measure the second element above, the dip, may be judged from the values above written, obtained by trained observers in a fixed observatory of the first class with standard instruments.

The extreme range of values of dip resulting from semi-weekly determinations from Jan 3d, 1879 to Oct. 7th, 1881, 288 determinations, was only 11 minutes [19° 14′9 to 25′.7].

On October 8–10, 1881, the dip circle was taken to pieces, thoroughly cleaned and readjusted, and with the following result:—

From Oct. 4 (!) 1881 to Dec. 29, 1882 the dip was observed 137 times; the least determination was 19°37′.1 and the greatest 19°48′.4, being a very pronounced deviation from the result in the preceding series, and one which brings into conspicuous prominence the need of better means of measuring the dip.

In the first of the 5 appendices are some interesting bits of information, not technical, but of a more popular character.

The magnetographs used are patterned after those at Kew, and furthermore were tested at the Kew observatory before shipment to India in 1869. They are permanently mounted on stone piers in a subterranean room, the floor of which is 12 feet below the surface of the ground. This room is double walled —of stone—with an air space; has a teak roof covered with asphaltum and overlaid with earth. The approach to the room is by a lobby and staircase similarly guarded against temperature changes. Careful arrangements have been made to secure good drainage and ventilation. changes suggested by experience having been made with a view to greater efficiency.

With respect to uniformity of temperature the mean daily range is less than half a degree Fahrenheit (0°.4 exactly) and in only three months out of 83 did it reach 0°.7. The average *daily range* of atmospheric temperature we do not find in the volume but it is presumably small. If we assume it to be 16°, then the mean range of temperature inside the magnet room is about $\frac{1}{27}$ of the outside temperature.

In ventilation, the latest improvement consists in drawing fresh air directly into the magnet room at the floor during the day time, and into the magnet room via the box containing the sensitive photographic paper during the night.

The reason for the latter arrangement, effected in 1881, is thus stated by Mr. Chambers:

"When the underground room is "filled with a warm damp atmos- "phere, as in the months before the "commencement of the monsoon, "the sensitiveness of the photo- "graphic papers undergoes a serious "deterioration during the exposure, "and the formed images tend to fade "away so that the earlier portion of "the traces are feeble, whilst the "later portion of the same sheet of "paper are stronger."

"The ventilation through the box "containing the sensitive sheets was "devised to correct this, and with "satisfactory results."

A barograph records in the magnetograph room. The magnets are under bell glasses from which the air is largely exhausted, the pressure

varying from 2 to 3 inches or less. The sensitive papers are changed at 9:28 A. M. of each alternate day, except occasionally when the bad performance of the paper makes a more frequent change desirable. One attendant gives his entire attention to the photography of the observatory, sensitizing the paper, developing, fixing, etc., on each day of changing papers. The loss of record, therefore, from photographic and other failures has been very small.

If we have thus far dwelt with considerable detail on externals, and on the machinery by which results are obtained rather than upon the results themselves, it must be remembered that these are the features which are of more popular or general interest. Besides, excepting the Los Angeles Observatory, devoted to magnetism exclusively, no such establishment exists in the United States.

The first appendix is a very elaborate paper devoted to a full exposition of the method of obtaining the various constants of the magnetographs and to the results.

The greater part of it is taken up with the report of a very complete investigation of the peculiar behavior of the balance magnetometer at the *Colába* observatory. The theory of the balance or vertical force magnetometer rests on the assumption that the knife edge on which the magnet rests is a mathematical straight line. This knife edge is usually of agate, like the knife edge of a delicate balance and rests on an agate plane.

In the case of the Bombay instrument its peculiar behavior showed this assumption to be entirely inapplicable, and a very full investigation resulted in showing that the form of the edge was *not* a point; *not* a circle, though approximately a circle whose radius is 0.006 inch; not even an ellipse resting on its "side," though nearly so, but an irregular curve.

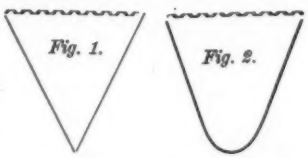


Figure 1 shows the ideal section and Fig. 2 is an illustration of the actual section. The curved part of this knife edge is represented approximately by an arc of 80° in a circle whose radius is $\frac{1}{110}$ of an inch.

Now some peculiar effects followed from this very small departure from perfection of construction. After the magnet had been horizontally balanced and was resting on this curved edge it performed satisfactorily until, through changes of temperature or force, or other causes, it became inclined to the horizon beyond a certain narrow limit when it passed from a condition of stable to a position of unstable equilibrium and became an oversetting balance. Moreover, an increase of reading of (say) one scale division in one part of the scale would be produced by an increase of vertical force of (say) its one-millionth part; while in a different part of the scale the same increase of vertical force would increase the scale readings (say) two divisions, *i. e.*, the scale value was variable, and was therefore to be determined not *once*, but many times in different parts of the scale.

To still further complicate matters these variable scale values were found to vary still further with temperature, so that, if a change of scale reading at a temperature t would indicate a change of the vertical force of its $\frac{1}{m}$th part, the same change at a temperature t' would indicate a different change, a change of its $\frac{1}{n}$th part. Hence it is obvious that in-

ferences in regard to change of vertical force from the records produced by this instrument are obtained only with great labor, and must be drawn with great caution.

It is concluded that the instrument is a better measure of small than of large variations of vertical force, and that its use should be restricted to that for which it was intended, viz., to measure *variations* of force, and therefore the custom of deducing for different scale readings equivalent expressions in absolute measure is defective and should be abandoned.

In the last appendix a few pages are devoted to a discussion of the effects of elevation on diurnal variations of declination and horizontal force by comparing results obtained 6 feet above ground and 7½ feet below. The results are chiefly negative in character. This leads us to suggest that the subject might be again investigated under more favorable auspices by maintaining a series of simultaneous magnetic observations at the top and bottom of the recently completed Washington monument. A comparatively short series at two stations, one vertically 500 feet above the other, would be sufficient to determine whether it was a promising field of investigation. M. B.

(67) *Appendix No. 13. U. S. Coast and Geodetic Survey Report for 1888.* **Account and results of magnetic observations at Ooglaamie, Point Barrow, Alaska.** *Made under the direction of the United States Coast and Geodetic Survey in Co-operation with the United States Signal Service Office at the United States polar station Lieut. P. Henry Ray, A. S. O., commanding post. Reduction and discussion, by Charles A. Tchott, assistant, U. S. Coast and Geodetic Survey. 4to.*

Washington, government printing office, 1884.

2 leaves unpaged, pp. 323-365, 1 map.

This publication is one of the series called *Methods and Results*, a series which, in the main, consists of separate prints or reprints of those appendices to the regular reports which are specially demanded. It deals entirely with the magnetic work undertaken by the International Polar Station near Pt. Barrow, Alaska, and is a very clear exposition of the magnetic work undertaken there and the results.

This station was discontinued in the summer of last year, 1883, and, in the late autumn, the instruments, observers and records reached Washington. In due course the magnetic records were turned in to the Coast Survey office and submitted to a critical examination, study and analysis. The result is now before us, and as the discussion and preparation for publication have been made by Mr. Schott, so long and so actively at work on terrestrial magnetism, we are not surprised to find his work most thoroughly and satisfactorily done.

Arrangements were made by the Chief Signal Officer to participate in the work of the International Polar Conference by establishing two stations, one the ill-fated Greely expedition and the second the Pt. Barrow station, to the charge of which Lieut. Ray was assigned. The Coast Survey co-operated "incidentally" the first year and somewhat more fully the second year, but owing to the want of time for procuring suitable instruments and trained observers was unable to co-operate in all details to the full extent called for by the circulars of the conference.

The period of observations is from Dec. 1, 1881, to Aug. 27, 1883. The party arrived on the ground Sept. 8, 1881, were housed Oct. 3, began meteorological observations Oct. 17 and magnetic observations Dec. 1.

With slight interruption hourly

readings were made from Dec. 1, 1881, to Sept. 9, 1882, on the declination magnet of the magnetometer used in absolute measures; of a portable bifilar, for variations of horizontal force and upon a dipping needle weighted. During the second year the old Brooke magnetometers were in place and yielded hourly readings of variations of declination, of horizontal force and of vertical force, from Sept., 1882, to August, 1883. The special "term day" readings on the 1st and 15th of each month were made during both years. It is of interest to note in passing that these old Brooke magnetometers have seen service many years, having been in use in a subterranean vault in the Smithsonian grounds in 1853; afterwards were in use at Key West, Florida, 1860–66; then at Madison, Wis., 1877–1881; whence they returned to Washington, were in part remodeled and then sent to Point Barrow.

During the first year absolute declination measures appear to have been made at irregular intervals, instead of "on three consecutive days about the middle of each month;" while during the second they appear to have been regularly taken on the 14th and last day of the month.

Any one accustomed to computation and reduction of observations will at once recognize the great and perplexing difficulties confronting the computer beginning a reduction of these observations.

Concerning them Mr. Schott says: "The records and results herewith "presented are the outcome of faithful labor, and are believed to be an "acceptable contribution to our "knowledge of magnetism in high "latitudes, and it is thought that *in "the second year, at least,* (the italics "are ours) these records will prove to "be a valuable part of the material "accumulated by the several expeditions."

The estimate which Mr. Schott places upon the absolute declination determinations, 31 in number, from Dec. 11, 1881, to Aug. 14, 1883, is thus expressed:

"Placing little reliance on the de"termination in December, 1881, "* * * and omitting for the present "all results in 1882 and those for "1883 up to the middle of March we "have the following *reliable* values, "etc." Then follow two tables, one of 9 determinations made during the last 5 months of occupancy of the station, considered reliable, and the second of 21 determinations which are not pronounced unreliable, but of which it is only said, "we propose to use some of these differentially."

We add that out of these 21 months' observations of absolute declination Mr. Schott has succeeded in saving 12 months, and tabulates the mean monthly declination for each month from Sept., 1882, to Aug., 1883. The observations are so defective that the annual change could not be determined with any certainty.

The Dip observations made, sometimes 3 and later 2 times per month from Nov. 30, 1881, to Aug. 14, 1883, appear to be good. We say appear, since the observations themselves are not yet printed. The results harmonize with each other, and, with old determinations in the same locality and the probable error of a monthly determination, is found to be $\pm 1'.4$.

The measures of absolute horizontal intensity and of dip were made on the same days and by two methods, the ordinary method being supplemented by observations with the Dip Circle in accordance with Lloyd's statical method.

The resulting magnetic elements at the station of which the latitude is 71° 17′.7 ± 0′.3 N. and longitude 156° 39′ 45″ ± 2′ 30″ W. Gr. are as follows

Declination	35° 37′.2 E.	From hourly observations Sept., 1882, to Aug., 1883.
Dip	82 23.4	Monthly determinations Dec., 1881, to Aug., 1883.
Horizontal force (British units)	1.636	"
Vertical force	" 12.786	"
Total force	" 12.933	"

The annual changes in the foregoing quantities, in the order above written and with the usual notation is:

$\delta D = 15'.0$, diminishing. Very uncertain.

$\delta \theta = 1'.2$ "

$\delta H = 0.006$, increasing.

$\delta V = 0.010$ "

$\delta F = 0.010$ "

The relation between the relative and absolute measures of declination is only approximately known on account of extraordinary and uncertain torsion correction The differential series of declination observations by themselves, however, appear well and the resulting solar-diurnal variation deduced by Mr. Schott, is in accord with results obtained by Sir Edward Sabine from the series of nearly 2 years similar observations made by captain Maguire near Pt. Barrow, 1852–54.

The mean daily range in the motion of the magnet is 40′ and is almost the same in summer as in winter, the annual inequality being slight. The easterly declination is greatest between 7 and 8 A. M., and least at midnight. From midnight to noon the progress of the magnet's motion is very regular: from noon to midnight decidedly irregular.

In connection with this discussion we are glad to note that Mr. Schott calls attention to the long, undiscussed series of magnetic observations at Sitka. 1842–1867.

The bifilar observations, or observations of variations of horizontal force are—as we would expect them to be—inferior to the declination observations, the bifilar magnetometer being a more complex instrument than the unifilar, and its mounting and adjusting requiring greater knowledge and skill. The observers attempted to adjust both the bifilar and vertical force magnetometers to the degree of sensitiveness recomended by the Polar conference, but through an error of calculation, "not discovered by them till near the close of the observations," they were given an adjustment "fully double" that intended. The chief misfortune resulting from this is the loss of record of "many of the largest disturbances;" the deflections extending beyond the range of the instruments.

No special observations for temperature co-efficients of the force magnets were made, but an approximate determination was obtained by selecting 7 days of large temperature range, and reasonably free from magnetic disturbance, and then comparing scale readings and temperatures.

The mean annual temperature in the observatory was 19° F., and the monthly means ranged from 8° F. below zero in December, to 46° F. above zero in July.

The daily range of variation of horizontal force is nevertheless, fairly made out; the force is found to diminish pretty steadily from midnight to a minimum at about 7 A.M., then steadily increase to a maximum between 5 and 7 P. M. after which a pretty regular diminution sets in and continues till the morning minimum.

The vertical force variations present even greater difficulties in their reduction than do the horizontal force variations. They have been treated in the same manner as the bifilar observations and show that beginning with midnight the vertical force increases steadily to a maximum at about 6 A. M., then falls regularly to about 10 A. M., then irregularly to a minimum at about 9 P. M., after which the regular increase of force sets in.

The paper terminates with a table of auroral frequency and is accompanied by a sketch map of the station and environs, and a full table of contents. A fuller report with the observations *in extenso* is expected at some future time.

M. B.

CORRESPONDENCE.

"WEATHER AREAS AND THEIR MOVEMENTS."

TO THE EDITOR:—I have been engaged for some time in investigations similar to those suggested by Mr. Sherman in the November issue and discussed by Mr. Tracy in the December issue. Though I hardly thought it desirable to state my conclusions until I had more thoroughly tested them from every point of view, their views are very suggestive, and I have no doubt will induce others to enter this field; and I feel that perhaps it would be an advantage for any such to state my experience in this line, for I know from personal experience the desirability of an investigator knowing what others have done in the same field. I devoted a several months of continuous labor to the very point Mr. Sherman has suggested. The most of this time, however, was taken up in adding, subtracting and dividing in obtaining averages, for I found it necessary, in order to detect slow movements in the atmosphere, to eliminate as nearly as possible the rapid oscillations; and since the Signal Service data accessible were only means for single days or months, it became necessary to compute the means for periods of several days or weeks during long intervals of time, and for a large number of stations, requiring an amount of labor of no mean proportions. My results were, in the main, nugatory so far as tracing simple weather movements such as Mr. Sherman describes were concerned, though I was in several cases able to detect such movements. In one instance I followed a wave of cold weather which seemed to enter on the Pacific coast, and advancing slowly across the country, passed out upon the Atlantic. While the results obtained led me to believe that no simple movement like that spoken of by Mr. Sherman could be relied upon for weather prediction, I became convinced that there was a complex series of such movements. Instead of there being simply a series of weather areas of rapid movement and another of slow movement, there is, I think, a series of weather changes, or barometric waves, which occupy only a few days in their passage

of the continent, other series occupying a few weeks, others a few months, and others a few years. The changes of greater length can only be made perceptible on the weather map by more or less eliminating the others. But my labors led me a step farther—to the conclusion that these waves of different length were periodic in their recurrence; and farther still, to the conclusion that besides their motion of translation they were undergoing a series of seesaw oscillations on each side of a line of no variation. I presented in the August number of this JOURNAL a part of my labors on a barometric wave oscillating every twenty-five months from a maximum to a maximum. I also presented the method I have adopted for separating waves of different lengths of oscillation from one another. I worked out this twenty-five months cycle for twenty or more stations distributed over the United States; and every one of the results agreed in indicating that the point of greatest oscillation of the cycle, which was at first in the vicinity of the Lake Region, had a slow motion toward the west, and at the end of ten years was in the vicinity of the Rocky Mountains. Another point of maximum oscillation opposite in character to the first was by this time entering on the Atlantic coast from the ocean.

The idea I have arrived at by investigation (and not from theoretical considerations) is that if we could form a mental image of atmospheric movements, "the whole would show a complication like that of a vast ocean swell, on whose surface there rise large billows, which themselves bear waves of moderate size, covered by wavelets, that are roughened by a minute ripple." (Spencer's "First Principles," p. 268.) Since reading Herbert Spencer's chapter on the "rhythm of motion," from which the above quotation was taken, it has occurred to me that this complicated rhythmical atmospheric motion follows from the very necessity of the laws of motion.

The rhythm of atmospheric movements, and the possibility of analyzing them, so as to separate the movements of short periodicity from the longer ones, seem to me so probable from my investigations that I am extremely hopeful of the future of weather prediction. I am in hopes others may be induced to enter the same field, and perhaps the idea can be rendered so probable that our government may be induced to take hold of it, and push the work rapidly to the point of utility. The experience of the past teaches that the public seldom assists or encourages such work until useful results are rendered pretty certain. It was twenty or thirty years after Loomis, Espy, Redfield, and others had almost demonstrated that storms and weather changes of short duration had a motion from west to east that Congress could be induced to see any advantage in a weather-bureau.

It is well to state, however, that there are a number of able meteorologists who are extremely doubtful of the utility of such investigations as those under consideration, and it seems to be a requisite characteristic of an original investigator that he has a goodly quantity of self-conceit. If his ideas are accepted, he smiles and enjoys it; if not, he smiles still—though he does not enjoy it so well—for he almost invariably believes that the objections either arise because the objectors have not investigated the subject, or because they are blinded by preconceived opinions. Some investigators even go so far as to think that everybody else but themselves are blockheads, and it is a favorite conceit of investigators to compare their fate to that of Galileo; but let a man once become enthusiastic over an idea; let him feel his nerves once tingle with the thought that he is on the track of an important discovery and he becomes willing to undertake labors which to others seem extremely monotonous, and endure privations which few can understand. If

he is successful in attaining at the close of his labors only a part of what his vivid imagination painted, men call him a genius; if not, he gains the title of a fool (or lately, a "crank")

The latter class are much in the ascendency, though each investigator thinks he belongs to the first.

I have thus tried to present the subject from two points of view; but if I could inspire others with the hopefulness I feel on the subject, I think our field would be rapidly occupied by eager investigators.

H. H. CLAYTON, Jr.

THE TWILIGHT DISCUSSION.

TO THE EDITOR:—In answer to Mr. Bartlett's letter I desire to say that I considered the pyramidal outline to be a common feature of our red sun-sets, and therefore did not feel called upon to make any more pointed remarks than to say that his own description plainly proved the display to have been nothing more than "a fine example of our red sun-sets."

I fancy that the statement, "It is evident that the uncouth forms.....are not explicable by the familiar laws of optics" (as ordinarily applied to twilight phenomena) is rather stronger than your correspondent intended; for in reasoning upon the probable cause of an unusual occurrence, one would naturally first look for an explanation involving certain known laws. But your correspondent does not even attempt to show that the applications of known laws fail to account for observed facts. Because an observer cannot think of a simple explanation involving known principles, it is not necessarily "evident" that such an explanation is unknown.

Now, an occasional feature of our ordinary twilight illumination, especially during the first half hour after sun-set, is just this pyramidal outline, and the same explanation which accounts for this appearance can also be applied to the phenomena of red sun sets.

Particles of *any* known form of visible matter suspended in the atmosphere may, for one arrangement (as when thinly distributed in a layer of great thickness, through the upper portion of which the red rays pass, while lower down the blue rays predominate; the mixture of the colors on reaching the eye producing a whitish light) cause ordinary twilight; while another arrangement of the same particles (as when they are condensed in a thin layer) may produce a colored twilight.

The clouds afford a familiar example of the latter case.

With reference to the sentence. in my letter, called *obscure*, "meridian distance" should read "meridian zenith distance." As a proof-sheet did not reach me the correction could not be made.

Respectfully,

J. M. SCHAEBERLE.

ANN ARBOR, Jan. 12, 1885.

ABNORMAL REFRACTION.

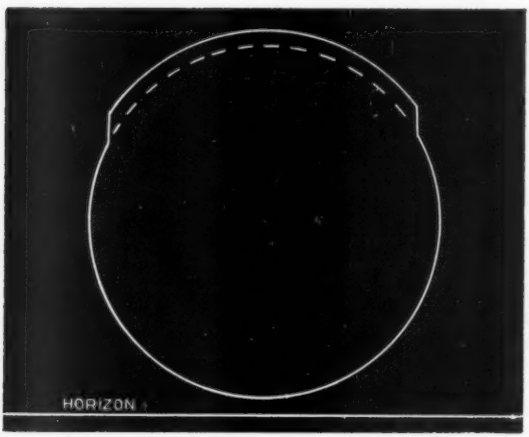
TO THE EDITOR:—I send you a rough sketch of an appearance of the sun seen on the 18th inst. near sunset, by Mr. Frank Proctor and wife of this place and myself, as we were riding out together, on that date, some two miles west of the city.

I think the phenomenon somewhat rare, as I had never witnessed it before nor since, neither have I noticed any allusion to it in my reading on the subject of optics. I should estimate the duration of this appearance at 30 seconds at least.

Have you ever witnessed anything like it? What is your idea with reference to its cause?

A. E. HAYNES.

HILLSDALE COLLEGE, Nov. 25, 1884.



THE GRIFFITH CLUB MICROSCOPE.

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F. L. James, M. D., Ph. D., Editor Microscopical Dep't "National Druggist," St. Louis, Mo,:

For general work, especially for students who have no fixed habitation, I think the Griffith Club perfection. The capabilitus of the model are unlimited. It will do whatever any other instrument can do. Its fine adjustment is excellent and embraces features which are possessed by no other instrument, with which I am acquainted; as to finish it is superb.

Robert Aberdeen, M. D., Syracuse, N. Y.:

I received your Griffith Club Microscope day before yesterday—set it up and like it very much in every particular.

Rev. A. B. Harvey, The Author Tannlon Maps:

It is, indeed, an admirable instrument; the best I know of, for what you clearly meant it for. A *multum in parvo* both as a home and a travelers stand.

J. T. Greenleaf, M. D., Owego, N. Y.:

The Griffith Club is a perfect stand. I don't want any better; can do any thing I want to with it.

Prof. Sarah F. Whiting, Wellesley College Mass:

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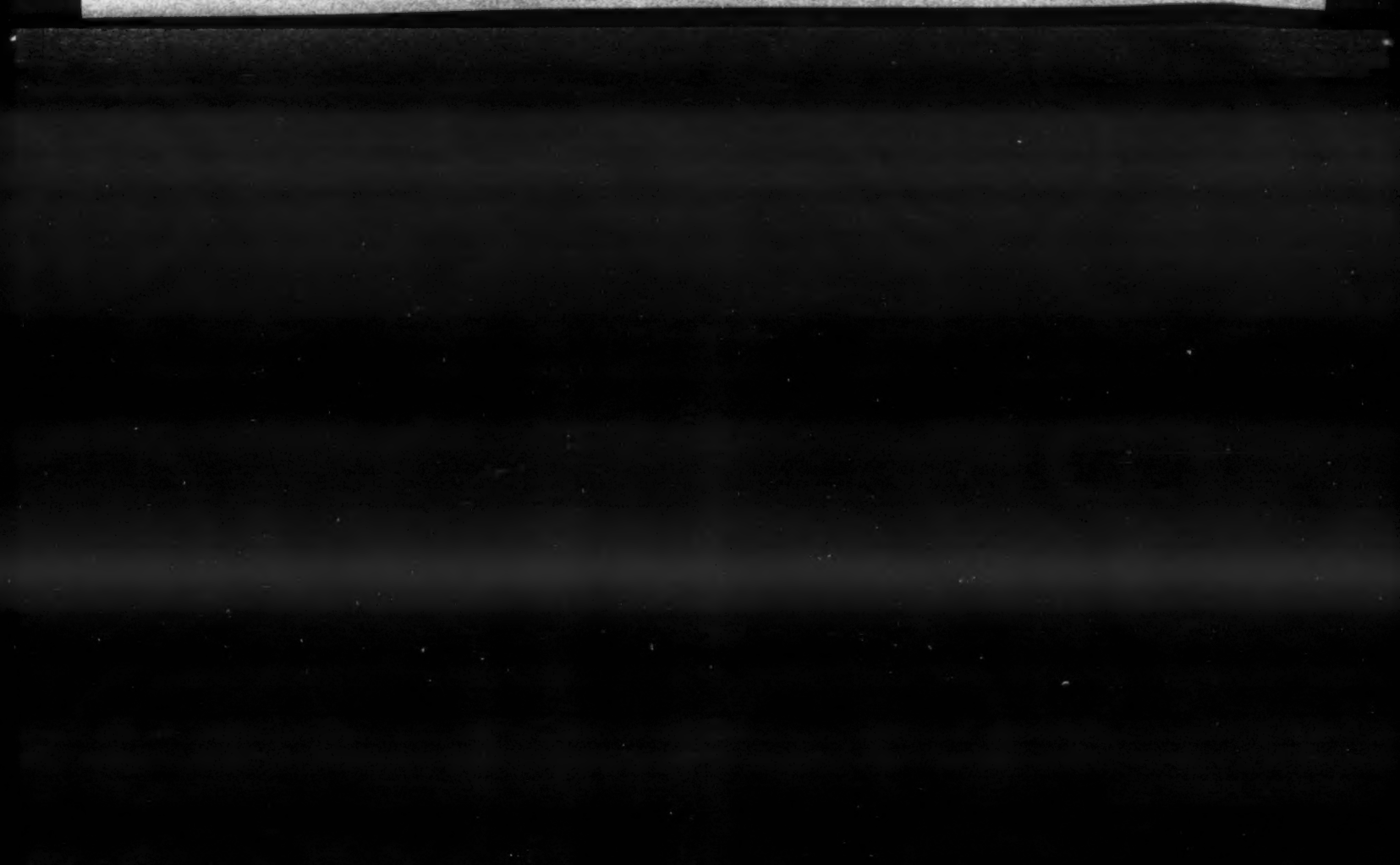

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